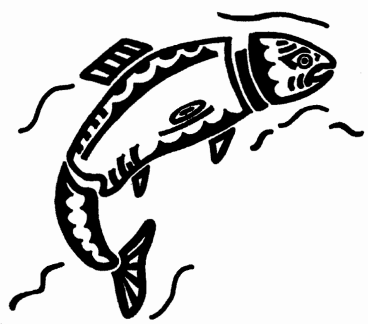
The Cost of Doing Nothing:

The Economic Burden of Salmon Declines in the Columbia River Basin



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REPORT NO. 1 OF 3 • OCTOBER 1996

Preface

The supporting data for this report was prepared for The Institute for Fisheries Resources under the direction of the Institute's Program Director, Mr. Glen Spain. This data was compiled and the methodology used in this report was developed by Dr. Hans Radtke, Natural Resource Economist, Yachats, OR in association with Shannon W. Davis, The Research Group, Corvallis, OR.

Dr. Radtke is an associate professor on courtesy appointment at Oregon State University and is a recognized leader in input/output analysis and natural resource economics. As a freelance economist, he has worked on a variety of fish industry related projects: impact analyses of management alternatives for Oregon Department of Fish and Wildlife since 1975; policy analyses of management alternatives for the Pacific Fisheries Management Council since 1985; Economic Assessment Model for the West Coast and Alaska Fisheries since 1984; impact analyses for the Bureau of Land Management on a variety of issues from 1981-1984; policy analyses and research projects for Oregon Coastal Zone Management Association, Inc. since 1986.

Mr. Davis is a systems research specialist with 15 years of experience in the field of planning. His professional interests are in single/multi-use natural resource planning and management with a specialty in resource economic modeling. Mr. Davis served on the Pacific Fisheries Management Council's Scientific and Statistical Committee during which time the Fishery Management Plan for Salmon Management was converted into a framework plan. He has completed many projects involving resource user surveys. He authored, for the Oregon Department of Fish and Wildlife, the Oregon Angler Survey and Economic Study in 1991 and A Study of Fish Resource Related Revenues and Costs: Sources, Uses, and Benefits in 1993. These investigative studies described the economic contributions of natural resources from angling and determined fish management program user fee levels and user benefits.

The report was prepared using methodologies with the understanding that technically sound and defensible approaches would be used. Where judgment became necessary, conservative interpretation was to be employed. Because this philosophy was strictly adhered to in all aspects of the report, this material presents reasonable and conservative estimates of the economic contributions of salmon, market conditions, and economic impacts.

This report is based on a reconstruction of historic salmon population figures originally generated by the Northwest Power Planning Council as cited herein. These figures have been well justified and peer reviewed, and are considered the best available reconstruction of historic levels of salmon populations within the Columbia Basin.

This is the first report in a series of three reports, including Report No. 2 (Klamath River Basin) and Report No. 3 (California Central Valley River Basins) using the same methodology. In this way we have estimated the number of salmon-generated jobs already lost to the economy due to policies allowing the decline of salmon as a resource in those basins. A full explanation of the basic methodology used in all three reports is contained (for brevity) only in this report, rather than duplicated in all three. This report should be referred to for the details of that methodology.

The report is prepared to assist in analysis and decision making and is based upon the best available information. The authors' interpretations and recommendations should prove valuable for that purpose, but no assurance can be given that decisions based on this data will fulfill expectations of market demands nor achieve any specific financial projections. Neither the study sponsor, nor any person acting on their behalf, makes any warranty of representation, express or implied, on the usefulness or accuracy of this information for commercial or any other business purposes.

Primary funding for this series of studies was generously provided by The David and Lucile Packard Foundation, with additional funding assistance for portions of these studies from the Pew Charitable Trusts, True North Foundation and the W. Alton Jones Foundation. All these foundations have become leaders in the effort to protect and restore the irreplaceable natural resources of the west coast. Their assistance is greatly appreciated.

Production layout of this report was done by Berkana Publications, Eugene, OR. The salmon graphic on the cover was adapted from original artwork created by Denise Sevigny, based on traditional block print graphics by the First Nations which occupied the Columbia Basin and used its resources on a sustainable basis for thousands of years before European settlement.

The Institute for Fisheries Resources is a nonprofit corporation dedicated to the protection and restoration of marine and anadromous resources. The Institute is also affiliated with the Pacific Coast Federation of Fishermen's Associations (PCFFA), the largest organization of commercial fishermen on the west coast, whose many members have been leaders in the protection and restoration of salmon habitat throughout the region.

 The issue of the cost to society of environmental destruction is one of the most important issues of our time. It is our hope that this report will shed some light on the very real costs of doing nothing to prevent that destruction in the Northwest.

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Executive Summary

Natural resources are the "natural capital" upon which all economies are based. Depletion of this natural capital through environmental pollution or waste eventually results in fewer economic options, a reduced job base and a net "economic drag" on regional and local economies. However, most costs vs. benefits analyses—and indeed traditional economic theory itself—does not take resource depletion into account as an economic factor. The result is that in any traditional economic analysis the economic effects of systematic and sometimes even irreversible destruction of natural resources (such as the Pacific coast's once abundant salmon runs) are dismissed as "externalities." In other words, the economic costs of environmental destruction are generally ignored.

Yet the consequences of environmental degradation rarely disappear. Widespread economic dislocation, very real job losses, and an overall reduction in the sustainability of the economy over the long term are often the result of environmental depletion. It may also result in additional costs to the taxpayer to remedy problems created by this destruction in the first place. In the case of the once abundant salmon runs of the Pacific coast, these problems have already resulted in *permanent* economic losses caused by the biological extinction of many commercially valuable salmon species. The American Fisheries Society has identified at least 106 major Northwest salmon runs as already extinct, and an estimated 214 additional salmon runs in Northern California and the Pacific Northwest are now at varying degrees of risk of extinction in the near future.[1] Habitat destruction and the impact of dams are both leading factors in these declines.

Wholesale destruction of salmon habitat and even dam construction throughout Northern California and the Pacific Northwest still continues. These impacts are continuing to drive the declines of many of the region's remaining salmon runs. However, there is a very real economic cost to society—in terms of lost jobs and forgone economic opportunities—of doing nothing to reverse this trend. Nowhere is this clearer than in the Columbia River Basin. The reality is that this "cost of doing nothing" can be very high indeed. The easiest way to quantify this cost is to compare the historic productive capacity of the river system with its current greatly diminished productivity, assuming all other things the same. This difference can then be quantified as the net economic drag created by the loss of these salmon runs in today's dollars and today's lost jobs.

> *The "cost of doing nothing" equals an economic loss of up to $500 million/year, which amounts to approximately 25,000 lost family wage jobs.*

1. *Nehlsen, W., J.A. Lichatowich, and J.E. Williams. 1992 "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington."* **Fisheries** *16(2): 4-21*

The estimated run size of 10 to 16 million fish that made up the pre-development Columbia River salmon runs could have made available about 125 to 237 million pounds to harvesters, assuming a modest 50% harvest rate. The harvesting, processing, and related economic activities of the Columbia River based salmon and steelhead fishery at the pre-development run levels, if available today at this 50% harvest rate, could potentially have generated economic benefits in the following ranges:

- **From $254 to $507 million of personal income annually;**
- **From 13,000 to more than 25,000 jobs, based on a full time equivalent annual job earning $20,000 per year, or about $10 per hour.**

The difference between these figures and today's dismal to nonexistent salmon harvests reflects the net economic damage done by Columbia Basin salmon declines. *The "cost of doing nothing" to restore Columbia Basin salmon runs amounts to an economic loss of up to almost $500 million/year in lost personal income, equivalent to the loss of up to approximately 25,000 family wage jobs*. However, this figure also represents the annual economic "dividend" which could potentially be derived from a social investment in measures to make the Columbia River Basin more supportive of fish. While full restoration to historic river fish populations is likely not possible, nevertheless this figure demonstrates that the economic dividend of even partial restoration can be very substantial indeed. In most restoration scenarios currently under consideration the economic dividend from a restored fishery may *more than repay the social costs of the necessary changes. In other words, it makes little economic sense* ***not*** *to restore salmon to as near as feasible to their once abundant levels.* Each additional salmon helps create jobs.

Viewed as the present value of a stream of annual income of this magnitude, this means that the *net asset value* of these lost fish is up to about $13 billion, using standard and widely accepted economic assumptions. *Maintaining the current regime of hydropower system mismanagement and habitat destruction in the Columbia River basin will thus cost society up to $13 billion in lost economic benefits from that fishery.*

Historically, the Columbia River provided jobs and income to tens of thousands of harvesters, cannery workers, and employees in related industries throughout the region. Adult salmon numbers in the Columbia River basin have fallen from between 10 and 16 million adults in the mid and late 1800's to about 2.5 million or less today. The vast majority of even these returning salmon are hatchery reared fish. A very general description is that, at the present time, about 95 percent of the returning coho are hatchery based. For chinook, the hatchery based percentages are 60 percent for fall chinook and about 80 percent for spring chinook.

Hatchery fish—unlike wild fish—require human dollars and energy to generate them, and are thus worth only a small fraction of the value of their wild counterparts (i.e., their net economic value is less hatchery production costs). In circumstances like the recent extremely low survival rates of hatchery fish generally, the cost of generating hatchery fish may in fact exceed their net economic value. In any event, it is clear that hatchery production cannot adequately substitute for the high survival rates and adaptability of wild fish, nor can hatcheries fully substitute for the loss of spawning and rearing habitat. Stringent protection of the remaining wild fish runs, coupled with an aggressive program of habitat restoration and hydropower dam passage reconstruction designed to restore wild fish populations thus continues to make excellent economic sense.

The Columbia River produces anadromous fish that are harvested in many different areas by different methods. These methods include troll fishermen in Alaska, charter boat patrons in British Columbia, gillnetters in the Columbia River, and subsistence, ceremonial, and commercial fishing by Indian tribes along the Columbia River. At present, there is no completed research that describes the separate economic contribution of the major salmon and steelhead species individually—whether they are harvested in or near the Columbia River or in other areas. To provide for such an investigation, coded wire tag information would have to be combined with economic impact calculation methods similar to the economic contribution analysis described in this report.

Maintaining the current mismanagement of the hydropower system and habitat destruction in the Columbia River Basin will cost society up to $13 billion in lost fishery benefits.

With limited data and disregarding the origin of the salmon, a $1.14 billion total personal income estimate was made for the 1989 recreational and commercial ocean salmon fishery from California to southeast Alaska. Another study estimated that about $1.25 billion of total personal income and 62,750 jobs were generated by commercial and recreational fishing for salmon and steelhead in the Pacific Northwest and Northern California in 1988. Other studies give comparable figures.

Columbia River salmon are primarily north migrating stocks. Thus historically they contributed to a large degree to the fisheries economies within regions far north of the mouth of the Columbia, as well as within the Columbia River itself. Even today, roughly one-third of the economic benefits derived from the harvest of salmon of Columbia River origin occurs in Canada or Alaska. The serious decline of Columbia River salmon runs, and the inequities this has caused between the U.S. and Canada, is one of the primary factors in the collapse of the Pacific Salmon treaty between the U.S. and Canada.

This study also describes how both anadromous fish hatchery programs and habitat improvement project economic values can be calculated:

- To estimate the economic contribution of a hatchery program, the egg to smolt survival rates are extremely important. Factors such as stream or river passage survival, ocean adult maturity survival, and harvest rates also have to be included. A conservative estimate of the economic contribution of a composite (spread among all user groups) adult harvested hatchery coho salmon is $19.13 using research conducted for conditions during 1988 to 1992. Assuming a two percent return-to-fishery harvest rate, the economic contribution of a single smolt is thus $0.38. This does not include the economic contribution of the hatchery operation itself, which may be about another $0.40 per smolt.

The hatchery cost per smolt produced varies from $0.20 to $0.80 per smolt, depending on which fixed costs are included. At a $0.25 per smolt cost, with a two percent fishery contribution, the adult harvested hatchery cost is $12.50. In instances of very poor survival rates, however (such as recently seen with a combination of habitat loss plus adverse ocean conditions) the cost of production of a hatchery fish may in fact exceed its net economic benefit.

- Habitat restoration creates substantial economic benefits. These benefits may be calculated by summing a series of yearly additional fish benefits in the commercial and recreational fishery. For instance, if a restoration project is designed to last 30 years, the total benefits are a flow of annual benefits accruing from the protective action over that time period. At $0.25 value per annual smolt, the capitalized value of each additional smolt in the harvest (seven percent discount rate and 30 year accounting period) is about $3 and at $0.80 is about $10. This means that a stream structure that is designed to produce an additional 75 smolts per year in a stream system is worth a total of $225 to $750. If additional smolts are produced, or under less stringent economic assumptions, the economic value of such stream structures could be far greater.
- The same principle may be used to estimate the salmon production capacity of a mile of stream. The goal of salmon management in Oregon is to return, on the average, about 40 fish per mile to productive streams. A pair of spawners may produce 75 surviving smolts. At a four percent fishery contribution, the annual economic impact of that mile of stream is thus about $1,100, or an asset value of $14,000 (at a seven percent discount rate and 30 year accounting period). Thus protection of the riparian area of a salmon producing stream for salmon protection alone can, in and for itself, confer substantial economic benefits. Other competing uses—such as grazing or logging practices—which degrade the biological productivity of these same riparian areas can greatly reduce those economic benefits.

This study also briefly discusses the relationship between forest management and salmon production. Coho salmon are used as an example for this relationship, because of current concerns about their listing under the Endangered Species Act. Efforts that improve water quality and quantity clearly will have complementary effects on all anadromous fish species present. Methods for calculating economic feasibility similar to the examples for coho salmon can just as easily be used for these other species as well.

With reasonable and carefully controlled harvests, average ocean conditions, and with an aggressive habitat maintenance and improvement program, a program to restore wild salmon populations is not only economically feasible but can produce substantial economic benefits on a sustainable basis, thus more than justifying the economic investment in restoration such efforts would involve.

Introduction

"The increasing loss of fish habitat, to pollution, unwise development and other human activities, is the single largest long-term threat to the future viability of the marine fisheries of the United States...Protection of habitat is the cheapest investment the nation can make to sustain productive fisheries..."[2]

The Columbia River Basin was once the most productive salmon river system in the world. Now, as a result of the deadly combination of massive hydropower dam construction (most built without adequate fish passage) and unscreened water diversions, coupled with excessive logging and overgrazing in the upper portions of key salmon watersheds which destroyed critical salmon spawning habitat, and exacerbated by a multitude of other human develop activities along the river, these once great wild salmon runs have now been reduced to 2-3% of their historic numbers. The remaining wild salmon runs in the Columbia are either already listed under the ESA or being considered for such listings in the near future. The Columbia and Snake Rivers themselves no longer resemble flowing rivers so much as a series of warm-water lakes which have become increasingly hostile to salmon. Not only salmon but many other fish species are dependent upon the Columbia River—fifty-two native fish species occur in the Columbia River system, 13 of which are found nowhere else.

Efforts to mitigate the economic losses this biological holocaust has caused through the artificial transportation of fish around the dams have failed, or are so seriously flawed that in some instances these programs actually exacerbated the problem. Technological solutions intended to be in lieu of providing river-like habitat conditions have proven both expensive and frequently counterproductive.

Rarely if ever is the economic impact of the loss of these runs considered as a part of the whole economic picture. Even more rare is any attempt by decision-makers to ascertain what these declines have already cost fishermen and fishing dependent economies in terms of lost jobs, lost economic opportunities and shattered lives.

This report estimates the lost economic value to society caused by declines of the wild Columbia River salmon and steelhead resource. It also estimates the annual economic damage done to regional fishing-driven economies resulting from these population declines in terms of lost jobs and lost personal income.

These estimates of economic impacts and the resulting asset values are sensitive, among other things, to annual landings, the proportion of the run size available for harvest, the time frame being considered, and the future discount rate and analysis period used to compute the net value. The assumptions chosen for this report are very conservative. Less stringent assumptions than those used in this analysis would yield greater projected values.

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2. *From Hinman and Safina, 1992. Summary and Recommendations. In: R.H. Stroud (ed), "Stemming the Tide of Coastal Fish Habitat Loss." Marine Recreational Fisheries Symposium 14:245-249. National Coalition for Marine Conservation, Savannah, GA.*

The economic value of salmon is expressed both in terms of annual revenue and resulting economic contribution to the regional economies of harvesting and processing salmon and steelhead, and in terms of total "asset value." The economic contribution is measured as household income potentially generated to harvesters (returns to owners, skippers, and crew members), to processors, and to supporting businesses. In economic terms, these are regional economic impacts measured by direct, indirect, and induced income generated by commercial fishing activity. The lost asset value is the net present value of the future annual income streams which could have been realized over the next fifty years had these declines not taken place. The end result is a preliminary estimate for the "cost of doing nothing"—i.e., the economic costs to society of allowing the present decline of what was once the most productive salmon fishery in the world to continue unabated. That cost is, in fact, quite substantial.

Conditions have radically changed, of course, since the first modern historical use of the Columbia River fishery has taken place. It is probably not possible to ignore all of the present demands on the Columbia River waterway or to expect that the fishery runs can return to historic levels without changes in present water use. However, many realistic measures can be taken to mitigate past practices and to help restore at least a large part of the currently depressed salmon runs in a cost-effective manner. The economic potential of the salmon resource, once restored, to repay what may be a substantial social investment in recovery measures depends on the economic value of the salmon resource to be recovered. This value establishes the level of the "economic dividend" that could potentially be achieved by recovery. As seen from the analysis, the value of this economic dividend is very large.

Many of the current fish-destroying land use and hydropower system management practices in the Columbia are not, in fact, necessary. Many cost effective strategies have been proposed which would allow both hydropower, timber harvest, grazing and other human activities to co-exist with salmon. Most of these strategies, however, will take an expenditure of money and effort as the social investment to get there. Among other uses for these figures is to demonstrate that such an investment is just that—*an investment*, and not a true cost. There will be a real economic return on that investment as a dividend, and this economic dividend will amply repay that investment over time.

The report is divided into sections. The first section briefly describes the history of Columbia River fish landings. Included in this section is an estimate of the pre-development run size on the Columbia River made by the Northwest Power Planning Council. The second section estimates the asset value of a stream of such landings over a fifty year period. The third and fourth sections discuss the economic contribution from salmon production in the Columbia River system all along the West Coast and possible ways of estimating the economic impact of hatchery and habitat improvement projects.

Appendix A discusses the economic impact methods used in this report, and estimates the amount of total personal income (and equivalent full time jobs) that could have been generated by these landings—and which could potentially be generated once again through restoration. Appendix B is a compilation of fisheries catch data which has proven to be useful in this and other economic studies.

Coho is used as a major species example for these calculations, because of its probable listing under the ESA throughout its range in California and Oregon. However, restoration efforts that improve water quality and quantity will have complementary effects on all anadromous fish. Methods for calculating economic feasibility similar to the examples for coho can be used for these other species as well.

Salmon are a cultural icon for the Northwest. In fact the Pacific Northwest was once defined as "anywhere a salmon can get to." Economics alone will not speak of the value of ceremonial salmon for the First Nations who live here, and whose lives and cultures are inextricably intertwined with salmon. Nor will it give us a value for the joys and memories of a small boy catching his first fish with a beloved grandfather, nor of the spiritual value of walking through a countryside filled with fresh air and pure streams which healthy salmon imply.

This report deals only with certain "hard" economic values which can be most easily quantified in terms of lost dollars and jobs. However, it should always be remembered that there are many other (non-market) social and cultural values which salmon also provide, but which unfortunately are outside the scope of an economics report. These other social values are nonetheless just as real, if not more real, than merely monetary ones.

With every extinction, some precious part of our cultural soul dies forever, though we may not be able to measure what that something really was in dollars and cents. Let us not forget, therefore, that the people of the Northwest are also "people of the salmon"—and that saving the salmon may also ultimately be the road to saving ourselves.

Columbia River Commercial Salmon and Steelhead Landings

The Columbia River drains a watershed that is 260,000 square miles, parts of which are in seven states (Oregon, Washington, Idaho, Montana, Nevada, Wyoming and Utah) and Canada. Anadromous fish, especially salmon and steelhead, traversed estuaries, rapids, and desert regions to spawn along the main stem and tributaries of its system. The 1,214 mile "raging river" known by the early Indians and settlers has practically become a back-to-back series of reservoirs from the Canadian border to Bonneville Dam near Portland, Oregon (Bonneville Power Administration 1987, Page 4).

The major alteration of the Columbia River system is relatively recent, but has had devastating effects on the run size and species makeup of salmon and steelhead resources throughout the basin. Today there are at least 60 major dams in the basin, including the 8 largest "main stem" federal dams (Figure 1) which block access to almost every tributary above Bonneville Dam. There are also thousands of smaller storage dams, including at least 2,972 dams in the Interior Basin, with 1,239 of those involving over 50 acre feet of water. Only 4% of these smaller dams are used for power generation.[3] Because federal inventory and inspection is only required for the larger dams and those with downstream hazard potential, and because state records are fragmentary, the total number of smaller dams in the basin is unknown, but certainly numbers in the several thousands. However, even small dams can block important fish passage and prevent spawning.

Most of the dams were constructed in the 1940's to 1970's (Table 8). It is difficult to estimate exactly what the runs were historically and what those runs might have been at the present time were it not for such changes as dam and irrigation development, industrial use and water pollution, human population growth, harvest practices, and hatchery policies. However, a comparison of what was, what could be, and what is provides a useful estimate of the "externalized" costs of development and the total effect of these dams and other impacts on the fishing-based economies of coastal and in-river communities.

Estimated Pre-Development Run Size

The Northwest Power Planning Council was established pursuant to the Pacific Northwest Electric Power Planning and Conservation Act of 1980. The Council was directed by the Act to develop a Columbia River Basin fish and wildlife program to protect, mitigate, and enhance fish and wildlife "affected by the development, operation and management" of hydroelectric facilities in the basin (Northwest Power Planning Council 1986, Page 1). In order to assess the salmon and steelhead losses attributable to hydropower development and operations, the Council developed estimates of "pre-development" run sizes. They used several methods and concluded that a 10 to 16 million fish run size is probably the most reasonable estimate (see Table 1, Northwest Power Planning Council 1986, Pages 14-17).

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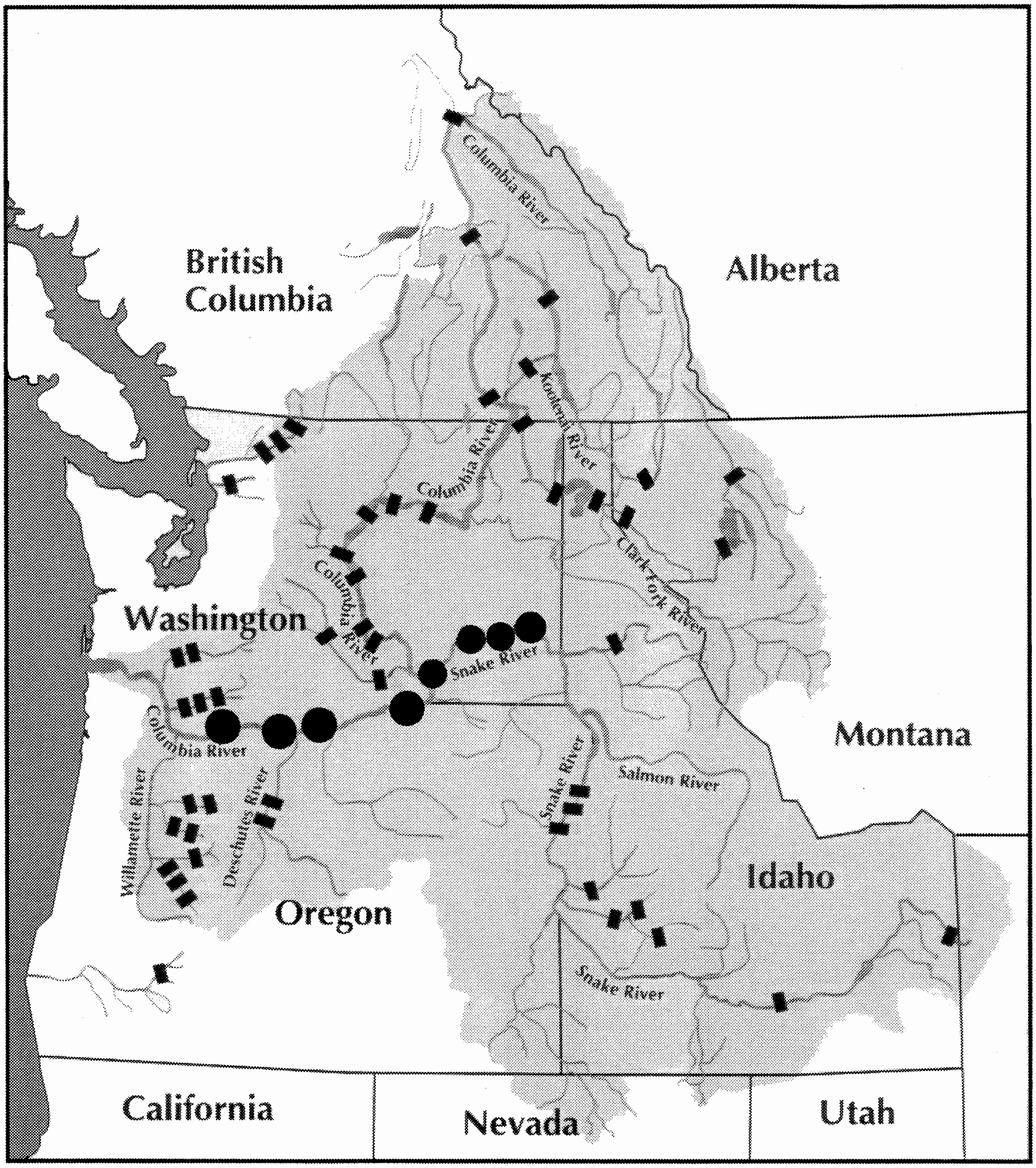
3. *Dam inventory data from Oregon and Washington state inventories.*

Figure 1
Major Dams in the Columbia River Basin



Courtesy Natural Resources Defense Council

Historic Commercial Harvest Ex-Vessel Value

Official commercial landings of Columbia River salmon and steelhead are only one indication of actual harvests. They do not include any Indian, sport, ocean commercial, ocean sport, or upper river non-Indian commercial/subsistence harvest. Also, by the time the first official landings data were completed, some environmental and harvest impacts had already occurred in the Columbia River system. Therefore, Figure 2 and the data in Appendix B should be viewed only as an indication of commercial salmon and steelhead reported landings. In order to show the total harvested run size, a representative per fish poundage was multiplied by each species. So that value of harvests could be compared, all landed pounds were multiplied by representative ex-vessel prices for comparable species as if they were harvested in recent years. Economic impacts were multiplied by representative per pound state level economic impacts.

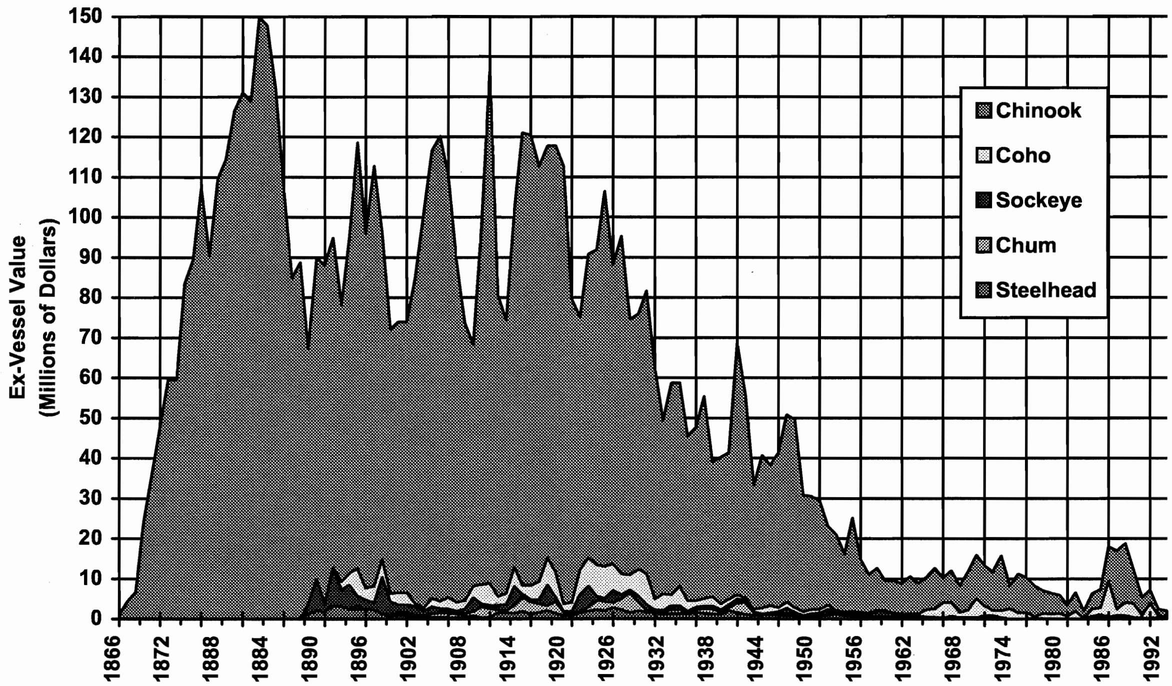
Table 1
Estimated Pre-Development Columbia Basin Salmon and Steelhead Runs

Species	Pre-Development Run Size (Range)			Current Run Size	Loss (Range)		
	67% Catch Efficiency Basis		50% Catch Efficiency Basis		67% Catch Efficiency Basis		50% Catch Efficiency Basis
Spring chinook	597	-	2,300	331	266	-	1,969
Summer chinook	2,537	-	4,600	125	2,412	-	4,475
Fall chinook	1,642	-	2,300	1,126	516	-	1,174
Sockeye	2,843	-	2,600	58	2,785	-	2,542
Coho	903	-	1,780	714	189	-	1,066
Chum	536	-	1,394	2	534	-	1,392
Steelhead	570	-	1,348	211	359	-	1,137
Total salmon and steelhead	9,628	-	16,322	2,567	7,061	-	13,755

Notes: 1. Run sizes in thousands of fish.
2. Current run sizes are 20 year averages. Current runs are almost entirely hatchery fish in origin (95% coho, 60% fall chinook and 80% spring chinook). Wild runs are now down to roughly 2-3% of historic run size, but these declines have been masked by the abundance of hatchery stock.

Source: Northwest Power Planning Council 1986.

Figure 2
Estimated Historical Columbia River Anadromous Fish Ex-Vessel Values Landed in Columbia River Communities



Please refer to Appendix B for historical catch data. The purpose of presenting the Appendix B information is to put the value of landings in some present context. For example, in 1893, the Columbia River gillnetters received $1 for each chinook landed. In ex-vessel value, this does not convey the real value of a spring or summer chinook that may bring about $3.00 to $3.50 per pound today (about $60 to $70 per fish). Comparing prices over a 100 year period is difficult. However, it is reasonable to compare volumes and respective ex-vessel values or income generated at representative recent year prices (1990 to 1994). Figure 2 and data in Appendix B show that in the Columbia River commercial fishery, the years in the late 1800's produced the greatest amount of poundage and resulting income to the region. As the effects of development took their toll and fisheries in other parts also started to harvest the Columbia River originating salmon, the run size and resulting economic contribution generated in the Pacific Northwest region of the Columbia River declined.[4]

4. *Estimates of fish harvested in other areas by different methods are discussed in later sections of this report.*

Estimates of the Asset Value of Historic and Current Salmon and Steelhead Runs of the Columbia River System

Appendix A discusses economic impact models and how those models can be used to estimate the economic contribution of resource use. Using these methods, this section estimates the asset value of pre-development Columbia River runs and more current levels of runs. Estimating the economic contribution of a resource use that has changed a great deal mandates simplifying assumptions. The major assumptions used for calculating the pre-development economic contribution are:

1. The ocean escapement, in-river returns are between 10 and 16 million fish.
2. Sustainable harvest rate is assumed to be 50 percent of ocean escapement.
3. The Columbia River salmon face a world salmon market. Prices do not change with the level of production because the world markets are eventually able to absorb the increased production and discontinuities are temporary.
4. Spring and summer chinook would be harvested by May and June.
5. All fish are assumed to be harvested commercially in the Columbia River. To bring in recreational and other geographic area harvests would complicate the analysis too much.
6. Ex-vessel prices of recent years are used in this exercise.
7. A 50 year financial period is used.
8. Discount rates of three to 10 percent are utilized as examples.

Pre-Development Run Size Ex-Vessel Value and Resulting Regional Economic Contribution

Historically, the Columbia River has provided jobs and income to thousands of harvesters, cannery workers, and employees in related industries throughout the region. Salmon numbers in the Columbia River Basin fell from between 10 and 16 million adults in the mid 1800's to about two million or less today. Most of today's Columbia River system returning salmon are of hatchery origin (about 95 percent of coho, 60 percent of fall chinook, and 80 percent of spring chinook). The reductions in commercial fishing jobs demonstrates only the direct effect of the contraction of the Columbia River based fishing industry. The associated decline in goods and services purchased from supply industries generates indirect impacts in the form of lost jobs and wages throughout the region. Reductions in the spending of household incomes from this industry affects workers in the general regional economy; these are the induced effects related to the fishing industry.

The estimated 10 to 16 million fish that made up the pre-development Columbia River fish runs could have made available about 125 to 237 million pounds to harvesters on the Columbia River (Table 2). At recent years' prices and at a 50 percent harvest rate these landings would have had the value of $136 to $273 million at the ex-vessel price level. The harvesting, processing, and related activities of the Columbia River based salmon and steelhead fishery thus might have generated $254 to $507 million annually in personal income. At a $20,000 full time equivalent wage or salary, this income could support from approximately 13,000 to 25,000 jobs annually (See Table 2).

In general, the income received by business sectors in the fishing industry is about 40 percent harvesters, 30 percent processors, and 30 percent other support and general businesses in the region.[5] Therefore, if commercial gillnetters on the Columbia River were the only harvesters of the Columbia River based salmon, they could expect $102 million to $203 million of income per year (based on pre-development runs). Persons employed in processing and in other supporting businesses could expect to generate about $76 to $152 million of income per year. The businesses in the region that sell goods and services to households that have received income from these fisheries affected businesses (the induced income) could also expect about $76 to $152 million of income per year.

Table 2
Annual Potential Ex-Vessel Revenues, Economic Impacts, and Jobs From Pre-Development Salmon and Steelhead Run Sizes

Species	Harvest (thousands)	Average Weight per Fish (Pounds)	Fish Weight (thousands of pounds)	Price	Ex-Vessel Revenues (thousands)	State Economic Impact per Pound	Total State Economic Impact (thousands)	Total Full Time Equivalent Annual Jobs
Spring chinook	299 - 1,150	20.0	5,970 - 23,000	3.25	19,403 - 74,750	5.75	34,328 - 132,250	1,716 - 6,613
Summer chinook	1,269 - 2,300	20.0	25,370 - 46,000	3.25	82,453 - 149,500	5.75	145,878 - 264,500	7,294 - 13,225
Fall chinook	821 - 1,150	20.0	16,420 - 23,000	1.00	16,420 - 23,000	2.20	36,124 - 50,600	1,806 - 2,530
Coho	452 - 890	9.0	4,064 - 8,010	1.00	4,064 - 8,010	2.20	8,940 - 17,622	447 - 881
Sockeye	1,422 - 1,300	3.5	4,975 - 4,550	2.00	9,951 - 9,100	3.75	18,657 - 17,063	933 - 853
Chum	268 - 696	12.0	3,216 - 8,352	0.60	1,930 - 5,011	1.75	5,628 - 14,616	281 - 731
Steelhead	285 - 674	8.5	2,423 - 5,729	0.60	1,454 - 3,437	1.75	4,239 - 10,026	212 - 501
Total	4,814 - 8,160		62,437 - 118,641		135,672 - 272,809		253,793 - 506,676	12,690 - 25,334

Notes:
1. Total number of fish from Table 1. Harvest range assumes a 50% harvest rate of pre-development run sizes.
2. Price is representative price per pound.
3. Economic impacts are measured in personal income in 1994 dollars.
4. Full time equivalent jobs are estimated using $20,000 of personal income per job, which is at or near regional median income.

Estimated Asset Value of Pre-Development Runs

The present asset value of a stream of future annual income can be compared to a contract that a person may have in his possession (or may be willed to him/her). For example, you receive as a gift from an uncle that passed away a contract (a house he sold) that brings in mortgage payments of $12,000 per year for 30 years. You desire to sell this contract for some

5. *Estimates made for this study using methods from Radtke and Jensen, 1986.*

value today, but what is it worth? In order to get a fair price, you would like to know what the asset value of that contract is today i.e., (its "present value.") At a seven percent interest rate, the asset value of this contract is worth $148,908. The asset stream may be considered an "annuity" and its present value calculated fairly easily (see page 45).

The same principal can be applied to a resource that produces a certain level of usable product per year. The question of who holds the contract (property right) is not addressed in this paper. Only the present economic valuation of a stream of future annual benefits is relevant here.

Based on a stream of annual benefits that could have been received by people living in the Pacific Northwest, the asset value of the salmon and steelhead resource, at pre-development level, ranges from $3 billion to $13 billion (Table 3). Discounted annual benefits are very sensitive to the interest rates used. A discussion of the appropriate interest rates is as follows:

Table 3
Estimated Asset Value of Pre-Development Salmon and Steelhead Runs at Various Discount Rates

Discount Rate	Range of Asset Value		
3%	$6,530	-	$13,037
5%	$4,633	-	$9,250
7%	$3,503	-	$6,993
10%	$2,516	-	$5,024

Notes: 1. Millions of 1994 dollars.
2. Based on economic impacts from Table 2 and a fifty year time period.

An evaluation of benefits or costs over time includes the cost of money over time which varies depending on the interest or inflation rate ("discount rate") assumed. The cost of money is usually reflected by the interest rate. At periods of 30 to 80 years, the discount rate assumed becomes the most crucial part of any economic analysis. Because many natural resource decisions made by public bodies involve a long time period, considerations are often given to the inclusion of lower discount rates—a social rate of discount.

A definition of the *social rate of discount* is a rate that should be used to compute the present value of benefits and costs of public investments and public policies if decisions based on benefit-cost are to be optimal. Concepts central to the discussion of the choice of the social rate of discount include (Lind et. al. 1982):

1. *Social Rate of Time Preference*—the rate at which society is willing to exchange consumption now for consumption in the future.

2. *Consumption Rate of Interest*—the rate at which individual consumers are willing to exchange consumption now for consumption in the future.

3. *Marginal Rate of Return on Investment in the Private Sector*

4. *Opportunity Cost of a Public Investment*—the value of the private consumption and investment foregone as a result of that investment.

5. *Risk*—which is related to the degree to which variation in the outcome of a public project will affect variation in the payoff from the nation's total assets.

There is no single discount rate adopted for use in all situations. The discount rate includes components of income taxes, risk, inflation, and the expected rate of return on investments. Economists argue the size for all of these components. Economic theory suggests that the rate of discount should reflect the return that can be earned on alternative investments. The Army Corps of Engineers and the Bureau of Reclamation, using Section 80 of P.L. 93–251, and most other government agencies set discount rates based on the cost of government borrowing. The present rate is about five percent but has been as high as ten percent. The U.S. Forest Service received a special authorization to use a four percent rate based on "real" (and after tax) return on forest investments. The Northwest Power Planning Council (the agency in charge of the Northwest's power system) uses a real discount rate of three percent in its analysis for evaluating resource alternatives.

Given the above discussion, and that the Northwest Power Planning Council uses a real discount rate of three percent, the argument can clearly be made that the asset value of the Columbia River salmon and steelhead fishery resource is roughly $13 billion. *That is, the region and its fishery dependent communities have lost or are about to lose an asset that is worth $13 billion to the region's economy.*

This $13 billion figure is the value of the "natural capital" of the whole Columbia River salmon resource, which if the present course of salmon declines is allowed to continue will be permanently lost to the regional economy. In other words, this is the ultimate cost of wild salmon extinction in the Columbia. This is also the potential economic benefit to the region from reversing these declines, which fortunately are still reversible.

By comparison, other studies have ascertained the asset value of the *present day* fishery, but only in its already severely depressed state. One such recent study concluded that Columbia River salmon production at present has been reduced in asset value to roughly only about $212 million (The Wilderness Society, August 1993). This present day value only underlines the magnitude of the historic losses— *up to approximately $12.78 billion remaining value has already been destroyed*. Also, since that study was completed (in 1993) present day declines have continued, bringing the total cumulative loss figures to still closer to $13 billion. Thus $13 billion remains a good estimate of the possible lost economic value of the rampant destruction of this valuable "natural capital" —the inherent "cost of doing nothing" to change the current destructive status quo. This also remains a good figure for the potential economic *benefits such changes could recapture for the region* — provided the necessary measures to protect and restore salmon in the Columbia are taken before extinction.

Current Run Size, Regional Economic Contribution and Estimated Asset Value

The economic contribution to lower Columbia River communities of more recent run sizes is shown in Table 4. The table shows averages between 1976 and 1992 and between 1992 and

1994. The table does not show how anadromous fish production from the Columbia River contributes to distant economies. In summary, the averages between 1976 and 1992 show that lower Columbia River communities received only about $3.3 million of personal income in ocean troll caught salmon, $10.0 million of personal income in ocean and Buoy 10 recreationally caught salmon, and $18.5 million from gillnet caught salmon. This totals to $31.8 million of personal income and compares to a total between 1992 and 1994 of $5.7 million. A segmented asset value, i.e. the asset value for the Columbia River communities, is $0.8 billion using the 1976 to 1992 average economic contribution, a three percent discount rate, and a 50 year accounting period. This very low value again reflects the economic devastation caused by several decades of land-use and hydropower dam-driven declines.

Table 4
Economic Contribution of Salmon Fisheries to Lower Columbia River Communities

	Index	Troll	Ocean Recreational	Gillnet	Buoy 10
1987	78.9	1,111	3,050		5,382
1988	81.9	573	1,056		8,198
1989	85.6	777	3,492		6,291
1990	89.4	557	4,404		3,098
1991	92.7	311	3,198		7,143
1992	95.3	128	2,035	1,840	4,768
1993	97.4	46	2,715	1,187	2,967
1994	100.0	1	0	1,092	371
1976-92		3,278	5,150		
1987-91				18,533	
1987-92					5,813
1992-94		58	1,583	1,373	2,702

Notes: 1. Economic contribution is in thousands of dollars and is measured in personal income that is adjusted to 1994 dollars using the Gross National Product Implicit Price Deflator developed by U.S. Bureau of Economic Analysis.

Source: Pacific Fishery Management Council 1994.

The Cost of Doing Nothing—Salmon Decline-Related Jobs Losses

The difference between the potential economic benefits of pre-development run sizes and today's dismal salmon harvests reflects the net economic damage done by salmon declines as a whole. The amount of annual economic contribution lost as a difference between what these salmon runs *could* have produced (up to $507 million/year) less their *current* contribution ($31.8 million/year using 1976 to 1992 average) is $475.2 million/year in economic loses. This is the equivalent of the loss of 23,760 lost family wage jobs. In fact, more recent job losses have been more than that, since in the years between 1992 and 1994 Columbia River salmon only generated $5.7 million in personal income—equivalent to a more recent loss of 25,350 family wage jobs, with virtually the entire fishery closed down. Preliminary figures from 1995 and 1996 indicate yet further declines.

Thus the "cost of doing nothing" to restore Columbia Basin salmon runs nearer to their historical productive capacity is an economic loss of up to almost $500 million/year in lost personal income, equivalent to the loss of up to approximately 25,000 family wage jobs.

Again, this figure also represents the annual economic "dividend" which could potentially be derived from a social investment in habitat protection and hydropower dam retrofitting such that the Columbia and Snake River systems were more supportive of fish survival. While full restoration to historic river fish populations is likely not possible, nevertheless this figure demonstrates that the economic dividend of even partial restoration can be very substantial. In most instances this dividend *will more than repay the costs of the necessary changes*.[6]

In other words, economically it makes no sense *not* to restore salmon to as near as possible to their once abundant levels, even at a relatively high net social investment, *because the ultimate economic dividend derived from doing so is going to be so high*. Clearly the more cost effective measures should be accomplished first—i.e., those measures which are likely to return the greatest number of adult fish to the system with the least amount of up-front cash investment—but these figures clearly show that there is a great deal to be gained for the region economically from expending the necessary funds and effort to recover this valuable resource.

Salmon recovery measures should thus be seen as they really are—wise investments toward restoring part of the region's "natural capital," and not simply as costs. For every dollar effectively invested by society into salmon recovery, there will also be substantial economic dividends received back ***by*** society just in terms of recaptured jobs, increased personal income and a restored community tax base, not to mention all other social, cultural and non-market benefits.

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6. *Projected costs of various retrofitting hydropower dams and other measures to reverse salmon declines are estimated to be in the range of $200–$300 million, many of them one-time (rather than continuing) costs. Some studies, such as* Changing the Current: Affordable Strategies for Salmon Restoration in the Columbia River Basin *(NRDC 1994) indicate that even these costs can be offset in a variety of ways, thus decreasing several-fold their ultimate costs as compared to their benefits. Compared to a potential "dividend" from such investments (due to a restored fishery) in the hundreds of millions of dollars* ***per year****, it is clear that salmon restoration efforts in the Columbia can be highly cost effective.*

Columbia River Salmon and Steelhead Production and Ocean Mixed Species Fisheries

With the introduction of motorized vessels capable of ocean fishing, salmon produced in any one watershed could be harvested throughout the Pacific Ocean. Salmon produced in Oregon fresh waters are harvested in the ocean from California to Alaska. At the same time, Oregon trollers and recreational ocean anglers harvest salmon that are produced in California, Washington, as well as some Canadian waters.

The Columbia River produces chinook and coho that are harvested in many different areas by different methods. These methods include troll fishermen in Alaska, charter boat patrons in British Columbia, as well as gillnetters in the Columbia River. For coho, over time, the production from Oregon streams (including the Columbia River and Oregon coastal streams) is about 40 percent of Oregon landings with a vast majority of the balance from California streams, although these ratios may vary a great deal between different runs from different origins. Chinook that are harvested off the Oregon coast are about equally split between fish of California and Oregon origin.

Estimates of the Economic Contribution by Salmon Species, Gear and Area Harvested

The economic impact of a specific species depends on the area it is harvested, by what means it is harvested, how it is processed, the price at point of harvest and point of primary processing, and the weight of the fish. Table 5 shows example economic values that a chinook may bring to the Pacific Northwest region in different areas when caught by different methods. The Columbia River fish harvested in any of the geographic areas of the Pacific Ocean by different methods may generate a variety of economic income per fish from $10 per troll caught coho to $144 for a gillnet caught spring chinook. For an explanation of the derivation of these total income estimates, please refer to Appendix A.

Estimates of the Economic Contribution of the Columbia River Fishery as Part of the West Coast Salmon Industry

At present, there is no documentation available that describes the economic contribution of the major salmon species produced in the Columbia River system on a species by species basis—whether they are harvested in the Columbia River or in other parts of the Pacific Northwest. To provide such documentation of the major species (in each of the major production areas), coded wire tag information would have to be combined with economic information similar to the economic contribution information described in this report.

With limited data, one estimate (Table 6) was made of the total personal income generated by the lower West Coast salmon fishery (California to southeast Alaska), regardless of the origin of the salmon. The estimate of the total income generated from ocean salmon fishing is about $1.14 billion. Another study estimated (Table 7) that about $1.25 billion of personal income and 62,750 jobs were generated by all commercial and recreational fishing for salmon, steelhead, and trout in the Pacific Northwest, at least as of 1988. (Pacific Rivers Council 1992).

Table 5
Species and Harvest Area Specific Economic Contribution

Salmon Species	Gear	Area Harvested	Ex-vessel Price (Round Weight)	Average Weight	State Level Economic Contribution Per Fish
Chinook	Troll	Puget Sound	2.04	5.92	28.22
Chinook	Purse Seine	Puget Sound	1.06	14.26	40.38
Chinook	Troll	Washington Coast	1.95	11.51	49.49
Chinook	Gillnet	Washington Coast	0.83	23.53	59.54
Fall Chinook	Gillnet	Columbia River	0.80	21.85	54.51
Chinook	Troll	Southeast Alaska	2.55	23.88	106.03
Chinook	Troll	Canada	1.61	18.70	75.74
Chinook	Purse Seine	Canada	1.07	14.60	43.07
Chinook	Troll	Oregon Coast	1.93	11.40	51.92
Chinook or Coho	Ocean Recreational	Oregon Coast	---	---	36.19 to 81.15
Spring Chinook	Gillnet	Columbia River	3.50	20.00	144.00
Chinook "Tule"	Gillnet	Columbia River	0.28	22.00	29.92
Chinook	Hatchery Returns	Columbia River	0.48	22.00	49.38
Coho	Purse Seine	Canada	0.73	5.60	13.05
Coho	Gillnet	Columbia River	0.86	6.90	17.76
Coho	Troll	Oregon Coast	0.90	4.56	10.39

Source: Radtke and Davis 1994 p IV–18

Table 6
Economic Impacts From Salmon Fisheries in 1989 by Areas That Impact Snake River Fall Chinook

Fishery Area	Economic Impacts
Southeast Alaska	$380
British Columbia	$616
WA/OR/BC Ocean Salmon Fisheries	$108
Columbia River	$33
Total	$1,137

Notes: 1. Millions of dollars.
2. Economic impacts measured in personal income.

Source: Radtke and Davis 1994 p IV–15.

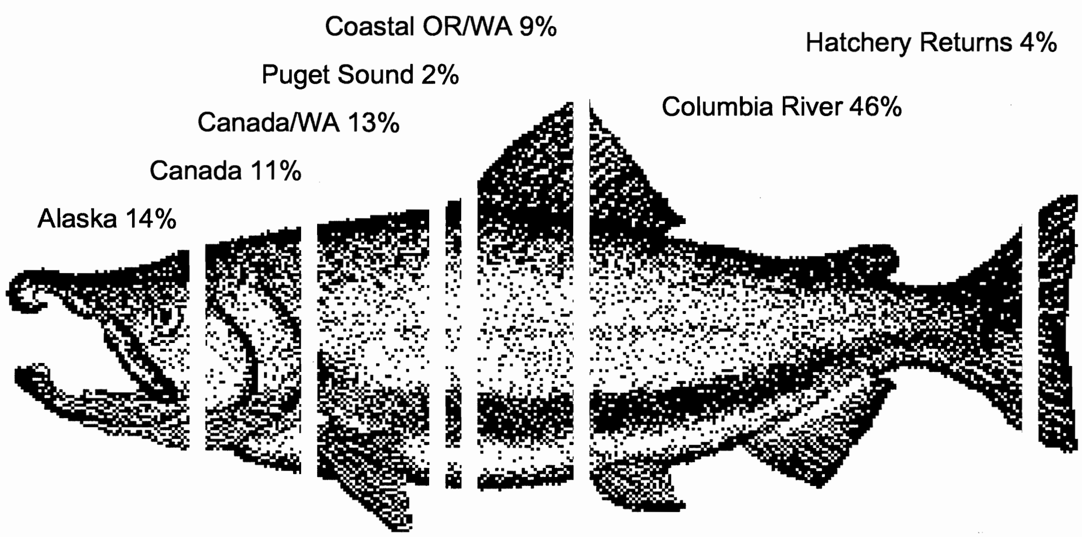
Not all salmon emanating from the Columbia River are caught and processed in the Columbia River or in Oregon and Washington. Personal income generated in different geographic areas by chinook salmon from the Columbia River system is depicted in Figure 3 and Table 6. Roughly one-third of the economic benefits from the harvest of salmon of Columbia River origin occur in Canada and Alaska.

Table 7
Fishery Related Economic Contribution in the Pacific Northwest

State	Commercial Economic Contribution	Commercial Jobs	Recreational Economic Contribution	Recreational Jobs	Total Economic Contribution	Total Jobs
Oregon	89,062	4,450	186,200	9,500	275,262	13,950
Washington	136,249	6,800	279,300	14,250	415,549	21,050
Northern California	94,723	4,000	372,400	19,000	467,123	23,000
Idaho	NA	NA	93,100	4,750	93,100	4,750
Pacific Northwest Total	320,034	15,250	931,000	47,500	1,251,034	62,750

Notes: 1. Economic contribution expressed in personal income in thousands of 1988 dollars.
2. Economic contribution from commercial fishing in Idaho is negligible.
Source: Pacific Rivers Council 1992

Figure 3
Columbia River Chinook Salmon Harvest Locations 1987-1991: Average Regional Personal Income Generated by Chinook Salmon Harvest by Geographic Area



Notes: 1. Estimates by Hans Radtke, Natural Resource Economist, Yachats, Oregon, July 1993. Mortality of fish by locations are taken from Morishima (1993).
2. Hatchery returns not harvested in the ocean or rivers are collected for the new brood cycle and carcasses and surplus eggs are sold.

However, as the Columbia River salmon populations have continued to decline there were fewer fish of lower 48 U.S. origin available to be harvested in Canadian waters to replace the fish of Canadian origin (also north migrating) caught in Alaskan waters. This growing inequity caused the collapse of the Pacific Salmon Treaty, which assumed a "one-to-one replacement" from each country to the other's fishery.

Columbia River System Salmon Mortality

Harvest by fishermen is only a small part of overall salmon mortality. Salmon traversing the gauntlet of the Columbia River system are more often killed by dams or as part of other human activities than by fishing. Table 8 shows that the construction of dams is a relatively recent impact to fish production. Figures 4 and 5 depict the effects of the dams versus harvests that smolts and adults face on their journey from and to their spawning grounds. For example, for Snake River wild spring chinook, out of a total of 4.5 million juveniles, about 600,000 may reach the ocean through a series of dam obstacles (Figure 5). Of these, about 30,000 may survive to adulthood. Some 4,000 may be harvested in the ocean and in the Columbia River. About another 13,000 will be killed as a result of traversing the same gauntlet of dams on their passage back up to their spawning grounds.

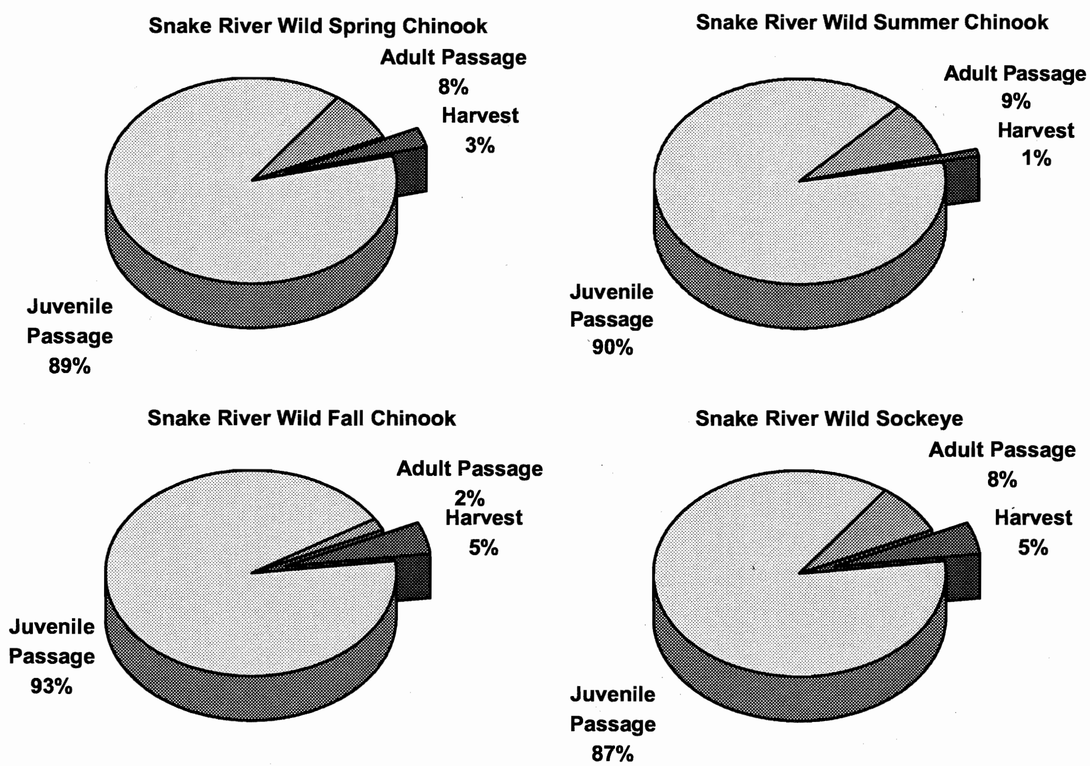
Table 8
Completion Dates of Columbia and Snake River Dams Which Affect Anadromous Fish

Dam	Year of Initial Service	Normal Maximum Head (feet)	Length of Reservoir (miles)
Columbia River			
Rock Island	1933	54	21
Bonneville	1938	62	46
Grand Coulee	1941	343	151
McNary	1953	75	61
Chief Joseph	1955	177	52
The Dalles	1957	85	24
Priest Rapids	1959	82.5	18
Rocky Reach	1961	93	42
Wanapum	1963	83.5	38
Wells	1967	72	29
John Day	1968	105	76
Keenleyside (Arrow)	1968	69	145
Mica	1973	615	135
Revelstoke	1983	425	80
Snake River			
Shoshone Falls	1907	212	
Swan Falls	1910	24	8
Lower Salmon (Salmon Falls)	1910	60	6
Upper Salmon A	1937	43	
Upper Salmon B	1947	37	
Bliss	1949	70	5
C.J. Strike	1952	88	
Brownlee	1958	272	57
Oxbow	1961	120	12
Ice Harbor	1961	100	32
Hells Canyon	1967	210	22
Lower Monumental	1969	100	29
Little Goose	1970	98	37
Lower Granite	1975	100	5

Source: Northwest Power Planning Council 1986.

Directed harvest is thus only a very small part of the total take of salmon. This fact also means that salmon recovery strategies that concentrate *primarily* upon restricting harvest are pointless—even if all harvest were totally eliminated, this would save only a *very* small fraction of fish when compared to the massive mortality caused by dams and related passage problems, not to mention various other forms of habitat loss throughout damaged watersheds.

Figure 4
Development and Harvest Causes of Immediate Mortality for Snake River Salmon Measured in Adult Equivalents



Source: Oregon Department of Fish and Wildlife 1994.

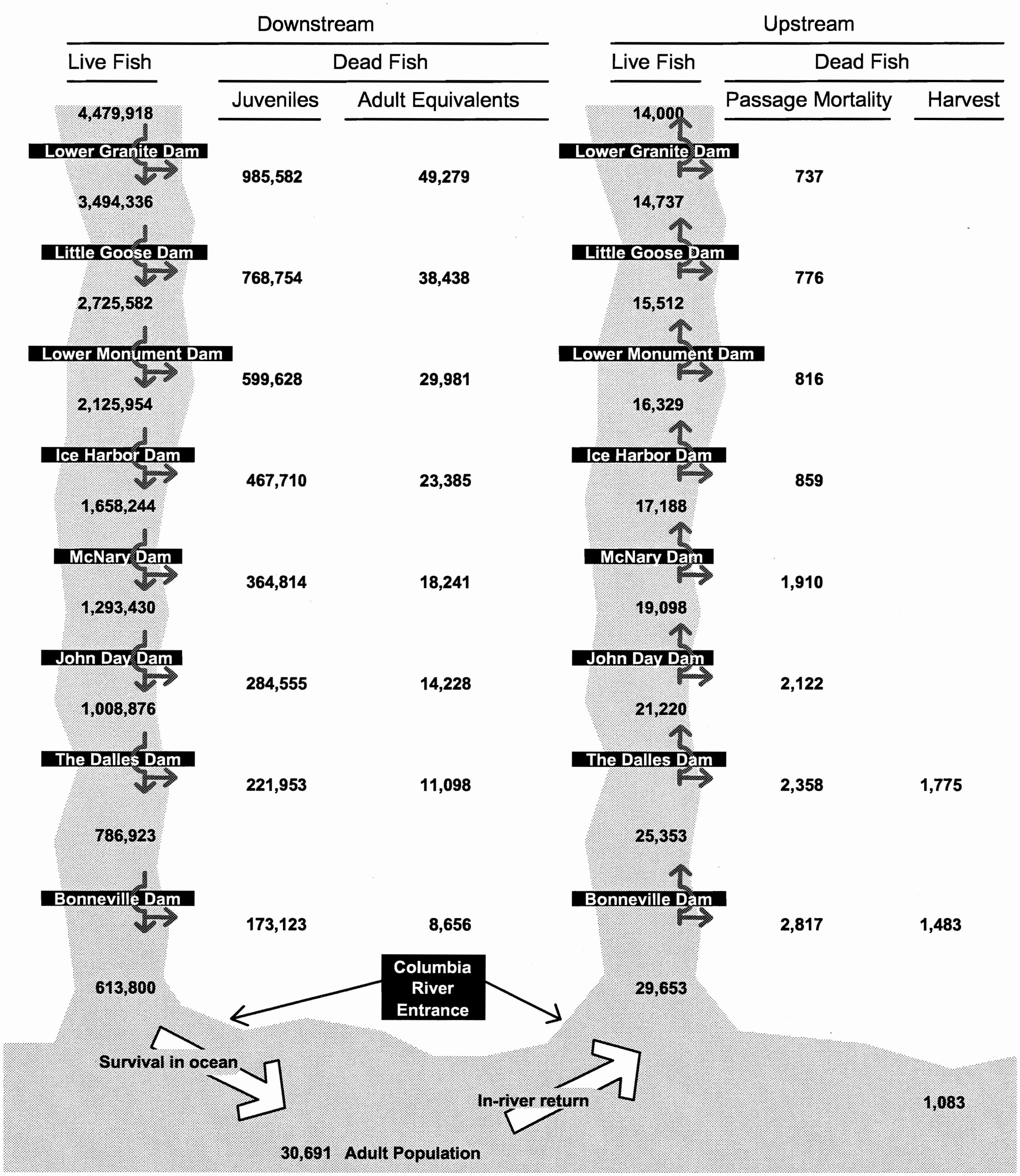
Hypothetical Example of Potential Cumulative Mortality in Juvenile or Adult Salmon Migration in Relation to Number of Dams Requiring Passage[a]

Passage Mortality for Individual Dams	Cumulative Mortality for Number of Dams Requiring Passage								
%	1	2	3	4	5	6	7	8	9
5	5	10	14	19	23	26	30	34	37
10	10	19	27	34	41	47	52	57	61
15	15	28	39	48	56	62	68	73	77
20	20	36	49	59	67	74	79	83	86
25	25	44	58	68	76	82	86	89	92
30	30	51	66	76	83	88	92	94	96

[a]Mortality numbers for individual dams vary.

Source: National Research Council (1996).

Figure 5
Passage and Harvest Mortality and Ocean Survival of Snake River Spring Chinook



Source: Oregon Department of Fish and Wildlife 1990.

Salmon Management and the Importance of Habitat Protection

Economic Contribution of Hatchery and Habitat Improvement Projects

With passage of the Magnuson Fishery Conservation and Management Act in 1976 (16 U.S.C. 1801 et. seq.), increased emphasis has been placed on coordinated salmon management. In the past, the emphasis of fishery management was in determining and managing for harvest levels only. Hatchery programs were specifically designed to mitigate for habitat losses for the benefit of creating harvest opportunities. The decline of private hatchery production, the questioning of the purpose of public hatchery operations, the effects from environmental conditions, and cumulative loss of freshwater habitat has meant that traditional management of harvest levels is only one of many important parts of modern fishery management. Habitat improvements and protection are now recognized as being critical to overall and long term anadromous fish production. This section discusses examples of how the economic contribution of hatchery programs, as well as habitat improvement projects, can be calculated.

In order to identify the economic contribution of habitat improvement projects, a descriptive matrix is needed that includes all uses of the salmon resource. Two examples are used to demonstrate what such a matrix may look like with a very rough outline of how economic impact values could be calculated. The examples are very general and should be considered explanatory only. The harvest shares, success rates, and dollar adjustments are for average or typical harvest levels and environmental conditions found during the 1988 to 1992 time period.

Example 1
Estimate of the Economic Contribution to the State Economy of a Composite Chinook Salmon

Chinook Salmon Use	Harvest Share	Success Rates Per Angler Day	Economic Contribution Per Day	Economic Contribution Per Fish	Economic Contribution Per Composite Fish
Ocean harvest	45%				
Commercial troll	75%			51.76	17.47
Recreational	25%				
Charter	18%	1.63	73.81	45.28	0.92
Private	82%	1.10	31.68	28.80	2.66
Estuary harvest	45%				
Commercial gillnet	50%			52.53	11.82
Recreational	50%				
Charter	10%	1.63	73.81	45.28	1.02
Private	90%	1.10	31.68	28.80	5.83
Hatchery harvest	10%				
Surplus (egg sales, fresh and fish meal)				17.02	1.70

Total State Level Economic Contribution per Composite Chinook					$41.42

Example 2
Estimate of the Economic Contribution to the State Economy of a Composite Coho Salmon

Coho Salmon Use	Harvest Share	Success Rates Per Angler Day	Economic Contribution Per Day	Economic Contribution Per Fish	Economic Contribution Per Composite Fish
Ocean harvest	45%				
Commercial troll	75%			13.20	4.45
Recreational	25%				
Charter	18%	1.63	73.81	45.28	0.92
Private	82%	1.10	31.68	28.80	2.66
Estuary harvest	45%				
Commercial gillnet	50%			15.85	3.57
Recreational	50%				
Charter	10%	1.63	73.81	45.28	1.02
Private	90%	1.10	31.68	28.80	5.83
Hatchery harvest	10%				
Surplus (egg sales, fresh and fish meal)				6.80	0.68

Total State Level Economic Contribution per Composite Coho					$19.13

The economic contribution of a hatchery program or habitat improvement project can use Example 2 calculations for coho.[7] To estimate the economic contribution of a hatchery program, the egg to smolt survival rates are critically important. Factors such as stream or river passage survival, ocean adult maturity survival, and harvest rates also have to be considered. The following is a crude estimate of a typical hatchery coho smolt economic contribution, based on actual revenues generated from fish harvesting and processing. The calculations do not include the economic contribution of the hatchery operation itself which may be about another $0.40 per smolt.

7. *Coho is used as an example because the species is experiencing severe declines and because of its likely listing under the federal ESA throughout its range in California and Oregon. The same example may be used to derive the economic contribution of other species.*

Example 3
Hatchery Coho Smolt Economic Contribution

	Harvest Share	Economic Contribution Per Composite Fish
Ocean harvest	45%	$8.03
Commercial	75%	
Recreational	25%	
Estuary	45%	$10.42
Commercial	50%	
Recreational	50%	
Hatchery sales	10%	$0.68

Economic Contribution of Composite Adult Wild Fish		$18.45
	Harvest Share	Economic Contribution Per Composite Fish
Economic Contribution of Composite Adult Wild Fish		$18.45
1% fishery contribution		$0.18
2% fishery contribution		$0.37
4% fishery contribution		$0.74
7% fishery contribution		$1.29
10% fishery contribution		$1.85
Economic Contribution of Composite Adult Hatchery Fish		$19.13
1% fishery contribution		$0.19
2% fishery contribution		$0.38
4% fishery contribution		$0.77
7% fishery contribution		$1.34
10% fishery contribution		$1.91

The calculated hatchery cost per smolt produced varies from $0.20 to $0.80 per smolt, depending on which fixed costs are included. At a $0.25 per smolt cost, with a two percent fishery contribution, the adult harvested hatchery cost is $12.50. For the hypothetical composite adult hatchery fish valued at $19.13 in the example above, the break even point is at about a 1.31% fishery contribution.

In other words if, as a result of the combination of hostile ocean conditions, disease, habitat destruction, poor adaptation or any of several other factors, the smolt to adult survival rates for these hypothetical hatchery fish were to fall below 1.31%, then the production costs of that hypothetical hatchery run of fish for adult harvest *would exceed its value*. Recent extremely low survival rates for hatchery fish generally (not uncommonly with smolt to adult survival rates as low as 0.1% to 1%), have caused this to happen. It is hard, under such circumstances, to justify the continuation of such programs to governments already facing severe budget deficits.

The same general procedure may be used to estimate the economic contribution of a wild spawner. For example, it is not unusual to have a three percent egg to smolt yield from a 2,500 egg deposit from a pair of wild coho spawners. The spawning pair provides 75 smolts into the estuary and ocean, from which two percent survive to be harvested in the commercial and recreational fishery and 2.7%, or about two fish, return as spawners. The two percent harvested thus contribute $27.68 of personal income to the state economy. With better ocean survival, at which four percent survive to be harvested and 2.7% return as spawners to meet escapement goals, the economic contribution of a single spawning wild pair is thus $55.36. Most importantly, the costs of production are essentially zero—Nature does all the hard work on her own nickel. Higher survival rates and zero production costs make wild fish far more valuable to the economy than their hatchery produced equivalents.[8]

Thus stringent protection of the remaining wild fish runs, coupled with an aggressive program of habitat restoration and hydropower dam passage reconstruction, continue to make excellent economic sense throughout the Columbia Basin. In any event, it is clear that hatchery production cannot adequately substitute for the high survival rates and adaptability of wild fish, nor can hatcheries fully substitute for the loss of spawning and rearing habitat. What is worse, hatchery programs are in some cases simply not cost effective. A far more cost effective strategy in the long run for maintaining a productive fishery on a sustainable basis is to protect and restore wild fish and their natural habitat wherever possible.

This is not to say that hatcheries are not a valuable tool when used to maintain fisheries production under appropriate circumstances, and so long as they do not adversely affect natural production. Where habitat simply no longer exists or is for all practical purposes permanently blocked by dams, mitigation hatcheries (such as the Mitchell Act hatcheries in the Columbia) are certainly the best remaining option if the alternative would be no fishery at all.

However, we should not fool ourselves into believing that artificial hatcheries are the functional equivalent of pristine habitat, nor that hatcheries can produce either the biological or economic equivalent of natural runs. Loss of habitat also affects hatchery fish survivals once released, and in addition the rearing conditions of hatchery fish make them inherently far more prone to disease and predation. Genetic interbreeding and food source competition between hatchery and wild stocks has also clearly exacerbated wild salmon declines in some instances. Thorough assessments of the effectiveness of hatchery programs generally have identified many serious problems (Bonneville Power Administration 1990), and recent scientific reviews have been very critical of production hatchery programs and urged many major reforms (National Research Council 1996). These reforms are now underway. Part of this reform effort should also be – but unfortunately rarely is – a clear strategy for making as smooth a transition as possible for the fishing industry away from its current almost total dependence on hatchery production (now about 70% to 80% in the commercial fishery) into a better harvest balance between naturally produced and hatchery reared fish.

Habitat protection also results in a series of yearly additional fish in the commercial and recreational fishery. If a project is designed to last 30 years, its value is a flow of annual benefits accruing over that time period. At $0.25 per annual smolt, the capitalized value of each additional smolt in the harvest (seven percent discount rate and 30 year accounting period) is about $3 and at $0.80 it is $10. This means that a structure that is designed to produce an additional 75 smolts per year is worth a total of $225 to $750.

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8. *In fact the source of hatchery fish is also ultimately the wild stocks themselves. Without those genetically diverse and superbly adapted wild stocks to periodically replenish hatchery genetics, ultimately most hatchery programs would collapse.*

This figure likely understates the impact of an additional wild coho smolt, because present ocean fishery management is constrained by the amount of wild coho available. In a mixed stock fishery, the ratio of wild coho to total coho and overall incidental coho mortality in chinook harvesting are primary limiting factors in setting overall harvest levels. Any additional wild coho introduced to the ocean system, therefore, allow an increasing amount of hatchery coho and more abundant chinook to be harvested commercially and recreationally.

The same principle may be used to estimate the productive capacity of a mile of stream. The goal of salmon management is to return, on the average, about 40 fish per mile to productive streams. Using the assumption that a pair of spawners may produce 75 surviving smolts on average and that there is a four percent fishery contribution, the annual economic impact of that mile of stream is about $1,100/year. This has a total asset value of about $14,000 at a seven percent discount rate and 30 year accounting period.

Important as salmon are to the economy, restoring the general conditions of streams and their watersheds also yields benefits far beyond the mere conservation of fishes. Other important, but often unappreciated natural processes (such as recharging groundwater aquifers and providing large woody debris to stream systems which assists in flood control) may also be helped. Water quality, recreation, drought resistance and flood protection can all be enhanced by improving the biological integrity of watersheds.

Factors Affecting the Annual Production of Coho Salmon

Overall watershed management is important in maintaining expected habitat for the breeding of anadromous fish. Upper watershed management includes protection of shading for cool water temperatures. Lower estuary management includes protection of escape routes and providing cover during a young salmon's journey from freshwater to saltwater. Important in-stream components affecting juvenile survival are gravel retention, woody debris retention, and water temperature. Gravel retention can be improved by better planning of logging and road construction and reconstruction. Woody debris and cool water temperature can be improved by leaving wide buffers of uncut trees along streams and rivers after logging operations.

Woody debris comes from trees growing near stream channels. The percent of total potential large woody debris that could end up in a stream is a function of buffer width. As illustrated in Figures 6 and 7, of critical importance to smolt production is the closest 100 feet of buffer, which provides the majority of infalling logs and leafy debris as a nutrient source for the aquatic food chain.

Other riparian characteristics also affect salmon productivity. Such factors as relative humidity, maintenance of a microclimate, buffers against blowdown and maintenance of soil stability usually require larger forested buffer zones, in many cases much greater than 100 feet to each side. Federal standards for key riparian areas under the Northwest Forest Plan, for instance, are therefore biologically based—no-harvest buffers to each side of the stream for a distance the equivalent of the average height of two "site-potential" trees (i.e., the height at which the average tree will generally grow in that soil type)—rather than specific numerical distances as in most state forest protection rules. Under state forestry rules, the largest buffers generally required are 100 feet to each side, with far less than that the general rule. These relatively minimal state buffer zones in fact have led to substantial long-term degradation of some of the most important salmon producing riparian areas in the region. Nonfederal lands comprise approximately 2/3rds of the range of salmon, but riparian areas on these lands are far more degraded than on the equivalent federal lands.

Relationships Between Forest Management and Coho Salmon Production

This section is a description of coho salmon distribution, life-history and survival, as well as a general discussion of the coho salmon relationship with inland habitat.[9,10] Coho salmon occur naturally only in the North Pacific Ocean and its tributaries. In the eastern Pacific, coho salmon are presently distributed in freshwater from Monterey Bay, California, to Point Hope, Alaska. In the western Pacific (Asia), coho are found from the Anadyr River, Russia, south to Hokkaido, Japan.

In the U.S., coho salmon have already lost considerable range in Northern California, Oregon and Washington. Estimates based on GIS mapping of historic versus present known ranges of coho in these three states show that coho salmon *are already extinct in 55% of their range,* and (according to status classifications by the American Fisheries Society), could be classified under the ESA as "endangered" in another 13% of their historic range, "threatened" in an additional 20%, of "special concern" in another 5%—and in only 7% of its historic range (mostly all in the Puget Sound area) is the species not known to be declining, either because it is presumed to be stable or because of simple lack of data (The Wilderness Society October 1993). In some streams in the southernmost portion of its range (northern California) the species' numbers are down to *one fish every few stream miles*, which is almost certainly too few to prevent localized extinctions. Widespread freshwater habitat loss has been identified repeatedly as a leading factor in coho declines. Among salmon generally coho are among the most sensitive to changes in inland and freshwater habitat because they over-winter for up to 18 months in inland streams—far longer than other salmon species.

Different life histories can also explain why two salmon species from the same stream can co-exist, as well as why of these two species one may be in serious decline while the other is stable or robust. Habitat impacts on coho come largely from upper watershed grazing and logging impacts, while habitat impacts on chinook (which tend to occupy the lower portions of a watershed) may be very different or have very different long term effects.

Populations of coho in the eastern Pacific center off British Columbia. Commercial catch records reflect production potential of the various geographic regions because coho tend to be caught close to where they originate. The relationship of abundance between regions remained fairly constant during the 60 year period shown, even though there have been considerable losses of habitat and increases in artificial production in some areas. A general increase in landings occurred during the 1960–69 and 1970–79 periods in British Columbia and areas to the

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9. *Coho salmon is used for description purposes because of the concern about the viability of California and Oregon coastal natural coho populations and their upcoming ESA listing.*

10. *Much of the material in this section is taken from Oregon Department of Fish and Wildlife (1982), developed as descriptions of coho habitat conditions on Oregon's privately owned forestlands. Salmon habitat conditions on public lands are generally better, though still degraded.*

south, perhaps as the result of increased hatchery production in Washington and Oregon. Oregon landings were greatly reduced during 1940–59. This probably resulted from loss of freshwater habitat and unfavorable environmental conditions, perhaps intensified by Oregon's position at the southern end of the range of coho salmon in the eastern Pacific.

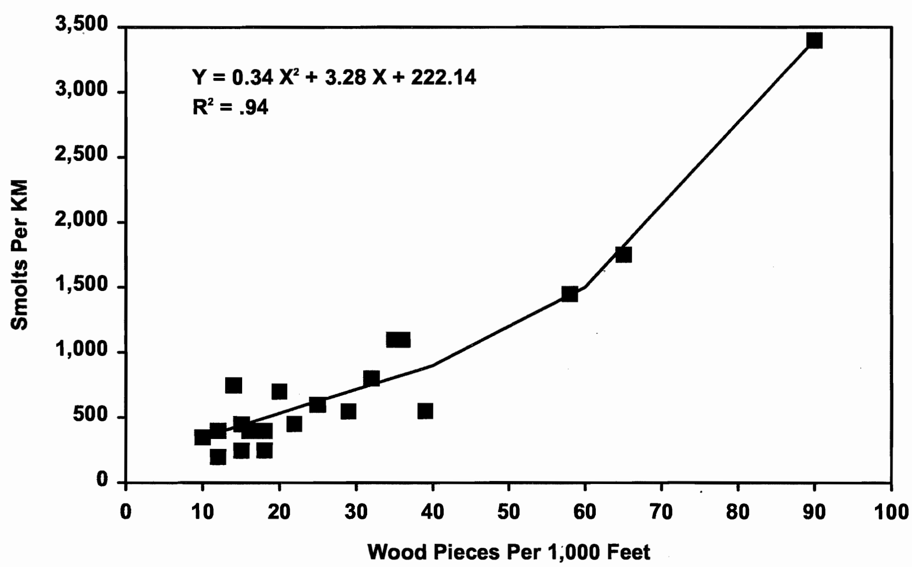
Figure 6
Coho Salmon Population Parameters Estimated for Present and Improved Woody Debris Availability on Private Forestlands in Oregon

Present and Future Conditions

	Pieces of Wood Per 1,000 Ft	Smolts Per Km	Egg to Smolt Survival	Smolts Produced	Adults Produced
Present	19.4	414	2.67%	2,650,000	106,000
Good Habitat (Coho Plan)	85	2957	4.40%	18,925,000	757,000
Preferred (Historic)	124	5857	6.40%	37,485,000	1,499,000

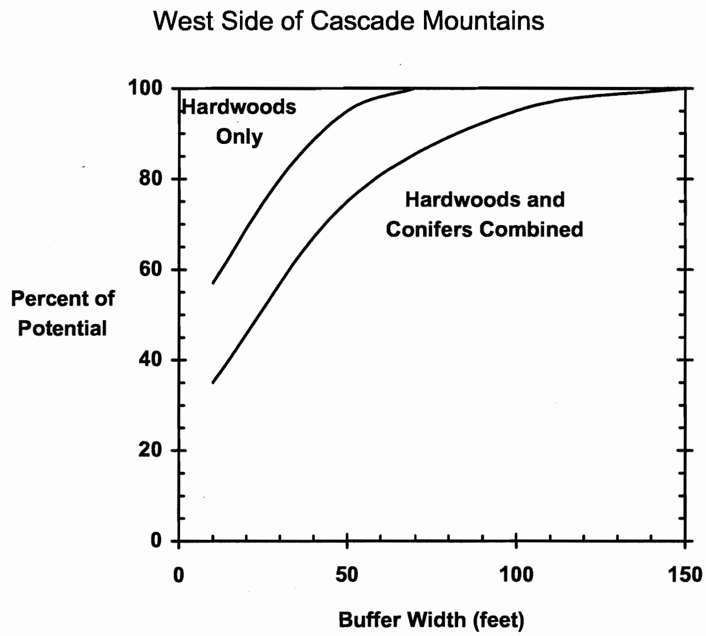
Assume:
1. 6,400 Km of coho salmon habitat.
2. Four percent survival from smolt to adult (memo from Steve Johnson, ODFW).
3. Current inventory of streams represents the 6,400 KM.
4. Historic production was one to two million adults, current production is about 100,000 (Nickelson et al. 1992).
5. Freshwater survival increases linearly as a function of potential smolt production (Y=6.79E-6X+0.024).

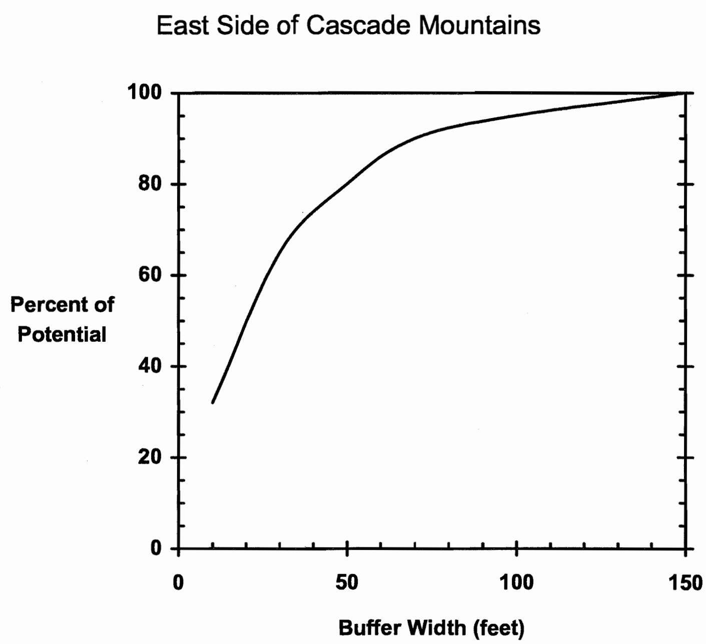
Coho Salmon



Source: Nicholson 1993.

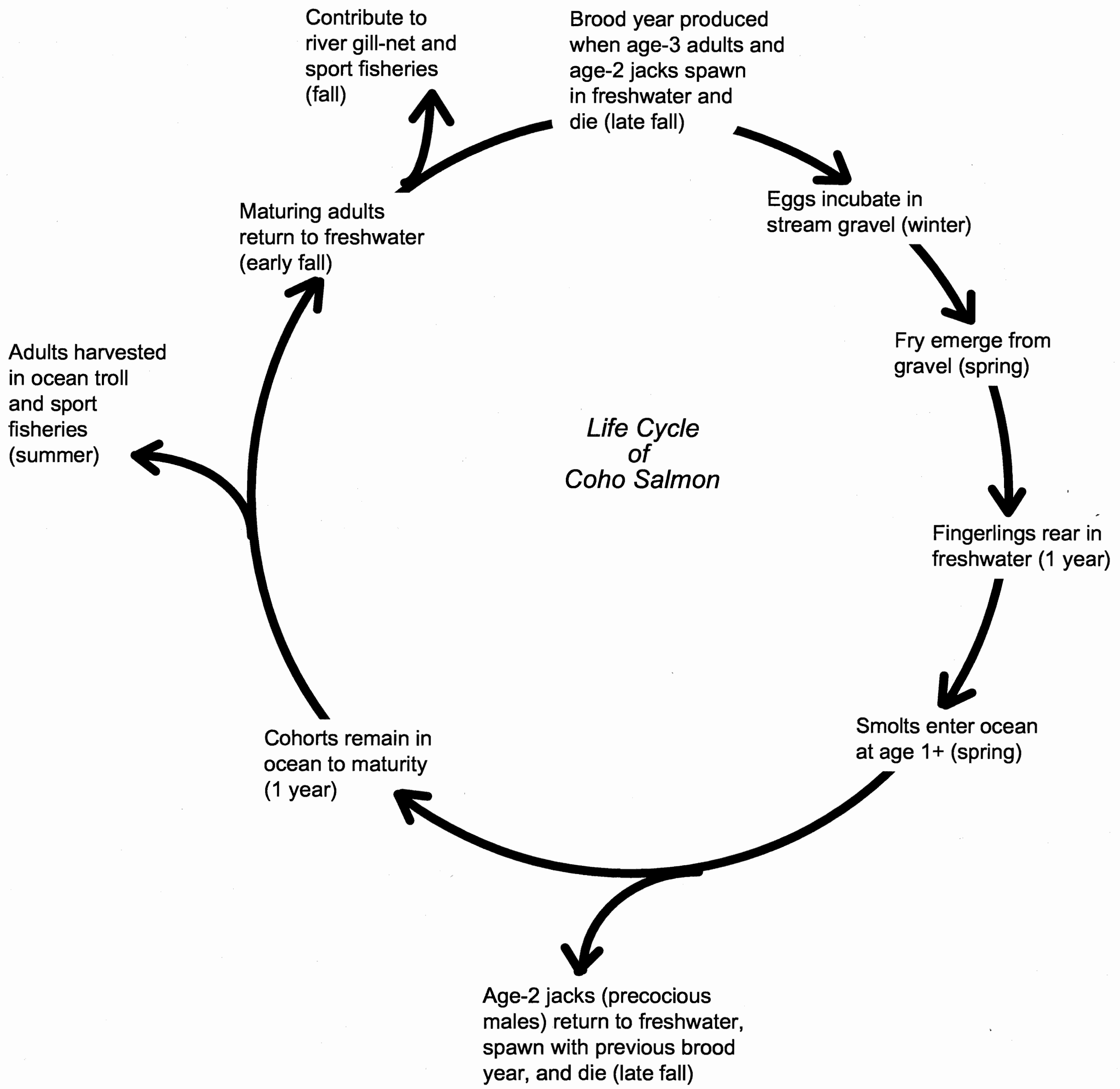
Figure 7
Percent of Total Potential Large Woody Debris That Could End Up in a Stream as a Function of Buffer Width (One Side of Stream)





Notes: The percent of total potential large woody debris that could end up in a stream as a function of buffer width on one side of stream.
Source: Oregon Department of Forestry 1992.

Figure 8
Schematic Diagram of the Typical Life Cycle of Coho Salmon



Source: Oregon Department of Fish and Wildlife 1982.

The primary features of the life cycle of coho salmon in their southern range are illustrated in Figure 8. Adult spawning coho are typically three years old and they are often accompanied by two year old jacks (precocious males) from the following brood year. Spawning occurs in tributaries in November through February. The parents normally exhibit strong site fidelity to their natural stream. The female digs a nest (redd) in the gravel and lays her eggs, which are immediately fertilized by accompanying males. The eggs are covered by digging and displacing gravel from the upstream edge of the nest. The parents die soon after spawning.

The eggs hatch in about 35 to 50 days, depending upon water temperature. The alevins (juveniles still with yolk sacks) remain in the gravel two or three weeks until the yolk is absorbed and emerge as fry to actively feed in the spring. After first schooling, the fry develop into fingerlings and become aggressive and territorial. Approximately one year after emergence, the progeny undergo physiological changes and migrate to the ocean as silvery smolts in the spring at about four to five inches in length.

The smolts undergo rapid growth, reaching about 15 to 20 inches in length by fall after feeding about six months in the ocean. After the first summer in the ocean, a small proportion of the males attain early sexual maturity and return to spawn as jacks. The cohorts remaining at sea, after jacks return, voraciously feed in the ensuing spring and summer, growing to about 23 to 33 inches in length by fall. During the second summer in the ocean, these maturing adults sometimes are caught in ocean troll and sport fisheries. As the adults approach full maturity, they re-enter freshwater in the fall where they support river sport fisheries before the survivors return to their home stream, spawn, and die to complete the cycle. The number of adults that survive to reproduce is dependent upon three primary factors: freshwater survival, marine survival, and harvest rates (Table 9).

Table 9
Potentials for Coho Survival Under Alternative Incubation and Rearing Programs

Type	Egg No.	Hatch Percentage	Hatched No.	Fry to Smolt Percentage	Smolts No.	Smolt to Adult Percentage	Adults No.	Egg to Adult Percentage
Wild coho salmon natural spawning and rearing	2500	3% survival from egg to smolt (average from 5 streams research in Oregon and Washington).			75	7.5% most optimistic estimate from Minter Cr.	6	0.2
Egg box incubation	2500	75-80% for eyed eggs; 48% for green eggs	1875	5%, same as unfed fry releases	94	7.5%, assumed same as wild	7	0.3
				10%, same as wild	188	same as above	14	0.6
Public hatchery presmolt released at 200/lb.	2500	87.4%	2185	Range: 3-10% Assumed 7.5%	164	same as above	12	0.5
Full-term public hatchery yearling	2500	Same as above	2185	79.7%	1741	2.53% 5.4%	44 94	1.76 3.76

Notes:
1. Eggs for wild coho are estimated average fecundity for coastal coho.
2. For wild coho, freshwater survival is density dependent; high egg survival results in low fry to smolt survival. Therefore, freshwater survival is best expressed as egg to smolt survival.
3. Survival of egg-box fry would probably range from 5% to 10%. Average survival would likely be on the low end of this range, since egg-box fry do not undergo the selection processes which wild fish undergo in the gravel. As with wild fish, density would also be a factor. Where eggs from hatchery stocks are used, survival would probably be around 5%.
4. For full-term public hatchery yearling, the range of data for % smolt to adult was 0.07-14.46% (average = 2.53% and average of yearly maximums = 5.4%). Since this table presents potential survival rates, the average of the yearly maximums is reasonable.

Source: Lettman, Radtke, Warner, and Griffiths 1993.

Conclusion

Economists often suffer from a peculiar type of blindness when it comes to including the costs to society of environmental destruction, the costs of species extinction, or the costs to future generations (not to mention present-day taxpayers) of pollution. It is no longer acceptable, however, to dismiss these costs entirely from costs/benefits balance sheets by labeling them "mere externalities" and simply ignoring them. Eventually someone has to pay for them. Also many of these costs can, if only the effort is made, be quantified or estimated and brought into the equation. When this is done in an honest way, many common industrial practices may be seen as more detrimental than beneficial to society as a whole.

At heart, economics only charts the flow of financial energy within society. It makes no sense to look at only the benefits half of the balance sheet, without deducting the societal deficits as well. In the real world, no business that counted only its revenues but ignored its production costs would long survive. So it is with our current society. If the basis of our economy is to be truly "sustainable" then we must total both the benefits and costs of social productivity.

As this report indicates, in the Columbia River Basin (and just in terms of lost salmon fishery jobs alone, without counting any other social costs) the current mismanagement of the extensive system of dams, combined with grazing and logging impacts causing upstream habitat loss (and by other related human development costs) have had a devastating impact on salmon. All combined they have all but destroyed what was once the most productive salmon river system in the world. Doing nothing to change these practices has a price. This "cost of doing nothing" can in fact be quite high. As this study concludes, the current destructive status quo has in fact eliminated as many as 25,000 family wage salmon-generated jobs from the economy—at a total cost to society of as much as $500 million/year. This is a price that is being paid each and every year in lost economic opportunities as well as in human suffering.

This is the bad news. The good news, however, is that it is not yet too late to reverse these declines nor to recapture many of these fishery-related jobs. Many practical and cost effective changes can be made in the dams themselves, some dams eliminated or relocated, others reconfigured, and these cumulative changes would greatly benefit salmon and help bring them back to harvestable levels. Logging and grazing in sensitive riparian areas does not have to happen in ways where salmon are affected, and represents waste of valuable fish resources that in most cases are far more valuable to society than the practices which destroy them. There are many salmon recovery plans and ideas already on the table which, if adopted and actually implemented, will help move the Columbia River Basin toward eventual recovery. What is in short supply is the political will to do what is necessary.

What this report highlights above all else is that paying for these changes is not a net social *cost*, but rather an *investment*. A recaptured fishery job base will bring back lost income, tax revenues and local food sources which are in danger of permanent extinction if these changes are not made. If the Northwest is to have a future which includes salmon it needs to make these changes soon. Once these valuable salmon stocks are extinct, it will be too late. Both biologically and economically, salmon extinction is the worst possible option.

Appendix A

Economic Impact Methodology Used

There are several uses of the Columbia River salmon and steelhead resources that generate economic value to the regional economy. This section presents a short explanation of the method utilized in this report to estimate economic value and the resulting job impacts.

Input/Output Models

Economic input/output (I/O) models are used to estimate the impact of resource changes or to calculate the contributions of an industry to a regional economy. The basic premise of the input/output framework is that each industry sells its output to other industries and final consumers and in turn purchases goods and services from other industries and primary factors of production. Therefore, the economic performance of each industry can be determined by changes in both final demand and the specific inter-industry relationships.

Input/output models can be constructed using surveys of a regional economy. The disadvantages of the survey model approach are its complexity and high cost. Construction of a survey data I/O model involves obtaining data on the sectorial distribution of local purchases and exports sold by each sector.

Another approach uses secondary data to construct estimates of local economic activity. The models developed for this progress report utilize one of the best known secondary input/output models available. The U.S. Forest Service has developed a computer system called IMPLAN which can be used to construct county or multi-county I/O models for any region in the U.S. The regional I/O models used by the Forest Service are derived from technical coefficients of a national I/O model and localized estimates of total gross outputs by sectors. IMPLAN adjusts the national level data to fit the economic composition and estimated trade balance of a chosen region. Details are presented in the Forest Service IMPLAN users guide (Alward 1987). I/O models have been constructed for the coastal counties. The same models used in this report are used by the Pacific Fishery Management Council (PFMC), Oregon Department of Fish and Wildlife, and other agencies to estimate the economic impact of alternative resource use.

Imports and Exports

One way of measuring the contribution of a particular economic activity is to look at the amount of goods and services it sells and buys outside the local economy. A local economy has exports and imports similar to state or national exports and imports. Timber harvested and processed in Astoria and shipped to Los Angeles is an export that benefits the local economy. The charter boat patron from Seattle brings money to the Ilwaco economy. Recreational activities are called exports when they bring in "outside" money. Exports from the local economy stimulate local economic activity.

However, the money brought into a local economy does not all stay in the local economy. This is particularly true for the smaller regional economies which are not economically self-sufficient. Many of the goods and services consumed in the local economy must be brought in from the outside. They are the imports to the local economy. The money that flows out of the local economy to pay for these imports is referred to as leakage.

In larger, more industrially diverse economies, there are fewer "leakages" of economic activity due to purchases from outside the region, and as a result the multiplier effects are larger. In smaller, less diverse economies where more goods and services are purchased outside the region, regional impacts are smaller. For this reason, state impacts will almost always be larger than impacts for regions within the state.

Basic Sectors

Since imports take money out of the economy, it is important for the smaller economies to have some exporting sectors. In the I/O jargon, these are called "basic sectors." The dollars brought in by basic or exporting sectors begin the multiplier process. The basic sectors stimulate a local economy by originating the multiplier effect. When people talk about a change in the economic base of an area, they are referring to a change in the basic business sectors.

Sectors other than basic sectors generally do not generate "new dollars", but rather operate on the circulation of dollars already present in the economy. Therefore, nonbasic sectors do not initiate a multiplier effect themselves, but instead contribute to the multiplier effect of basic sectors by preventing leakage. For communities on the Pacific coast, the basic sectors are often resource-based. Examples of basic and nonbasic sectors are (not necessarily in any order of importance):

Basic Sector Examples	Nonbasic Sector Examples
Fish harvesting/processing	Medical services
Logging and timber processing	Movie theaters
Tourism and recreation	Grocery stores
Transfer payments	Banking services

Transfer payments include such things as social security payments, retirement payments, and non-local government salaries. Activities such as recreational fishing would be considered a basic sector industry for that portion of expenditures made by anglers whose residence is other than in the area they are fishing.

Calculating Multipliers and Coefficients

Output (Sales) Multipliers

How is the effect of a dollar of export sales multiplied in a local economy? Suppose an industry increases export sales by $1,000. If the economy has an output multiplier of 2.49, total business sales through the county are expected to increase by a total of $2,490 as a result of the

$1,000 increase in exports and the $1,490 in local sales generated by these exports. (The 2.49 is used as an example only. The actual output multiplier may be different.)

Figure A1 demonstrates how local respending of the export payment by businesses and households creates this multiplier effect. The process begins when a dollar enters the local economy, in this case as the result of an export sale (column A). The dollar will be respent by the exporting firm in order to purchase inputs (goods, services, labor, taxes, profits, etc.) to meet the increased export demand (column B). Sixty cents of the dollar will be received by local businesses and households, but $.40 will leak out in the form of nonlocal purchases. Thus, in addition to the initial dollar, business respending has generated an additional $.60 of business activity within the economy. Of the $.60 that is locally received, $.38 will be respent within the county, and the rest ($.22) will leak out (column C). This process continues until the amount remaining in the local economy is negligible (columns D, E, F). Thus, greater leakage at any round of respending leads to a smaller multiplier.

In order to determine the total value, the initial dollar is added to the sum of the local respending. In this example, the multiplier equals 2.49 ($1.00 initial change + $.60 + $.38 +$.20 + $.12 + $.08 and so on until it approaches $2.49). Thus, $2.49 of local business activity will be generated for each dollar that enters the local economy. The same process can be used to explain the impacts of a decrease in export sales.

The output (sales) multiplier calculates how much money is "stirred up" in the economy, but it does not mean that someone in the local area is making a wage or profit from this money. The differences between output multipliers and income coefficients are often confused, leading to misuse. People, especially decision-makers, need to know and understand what type of multiplier or coefficient is being used in the assessment of the economics of proposed policy decisions.

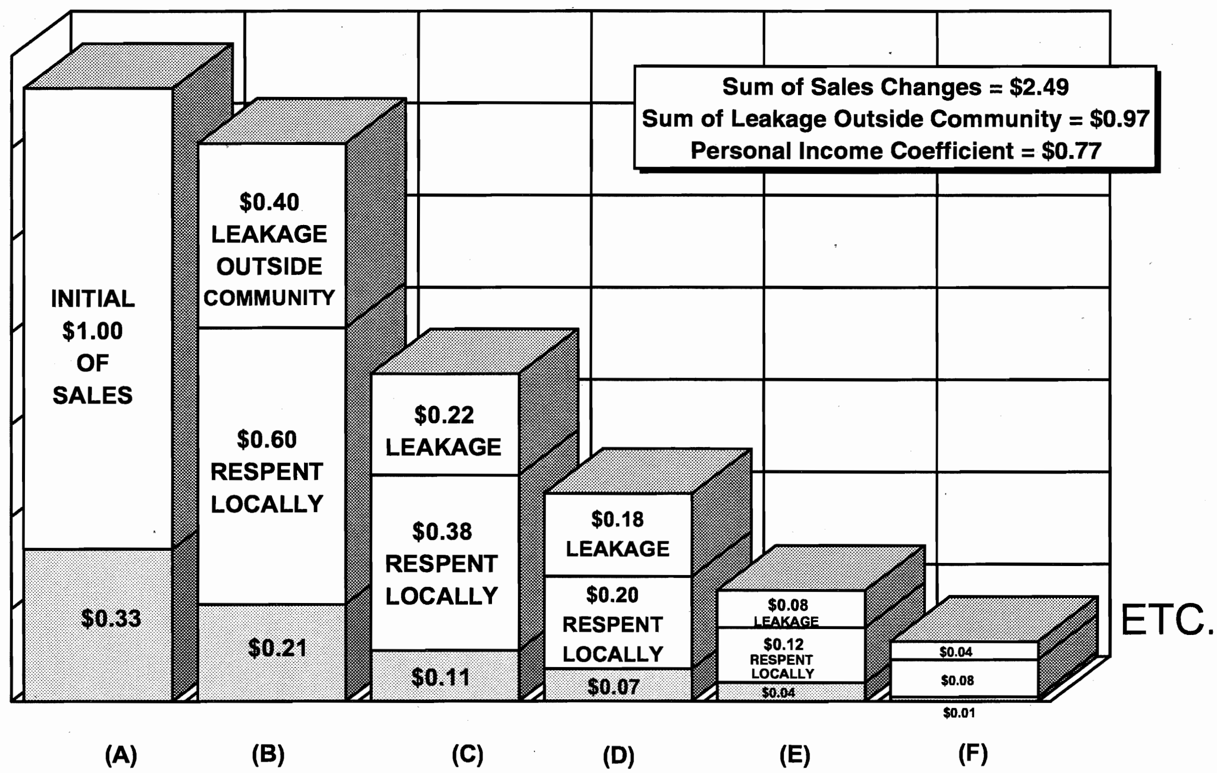
Personal Income Coefficients

A more useful measurement of the contribution of a sector's activity is the amount of local personal income that is directly and indirectly generated from an increase in sales. The distribution of the amount of local personal income generated is the shaded part of the output (sales) multiplier.

The "personal income coefficient" measures the income generated as a result of a change in sales. In the first round of export sales, $0.33 of local personal income is generated. The other $0.67 in the initial round goes to purchase supplies and services from other industries. These purchases in other industries also create wages, salaries, and profits. As these sales work through the economy, a total of $0.77 of personal income is generated from every $1 of increase in sales in this example.

The size of the personal income coefficient is largely determined by the amount of personal income generated by the first round. In an industry that is very labor intensive, the output (sales) multiplier may not be very large while the income coefficient is above average. On the other hand, if the industry goes through several transactions but is not very labor intensive throughout the process, the output (sales) multipliers may be large and the income coefficient small.

Figure A1
Output (Sales) Multiplier And Personal Income Coefficient



Note: The shaded portion of the output (sales) that goes to households in terms of wages, salaries, and profits is called personal income.

The impacts estimated in this report are effects on total personal income, the amount that is retained as household income (salaries, wages, and proprietary income). Because many jobs in the fishing industry are not full-time, an employment figure could be misleading. A full-time equivalent employment figure can be calculated by dividing the total personal income figure by a representative annual personal income average. In the Pacific Northwest, a $20,000 per year wage or salary is a fair representative of a full time equivalent job when considering all jobs that are generated by an activity, from waitresses to lawyers. The $20,000 figure is at or near the region's median annual income level.

Economic Fisheries Assessment Model For Communities on the Oregon Coast

Input/output models have been constructed for the Oregon coastal counties with the use of the U.S. Forest Service IMPLAN model.[11] On the commercial side, representative budgets from the fish harvesting sector (Figure A2) and the fish processing sector, as well as a price and cost structure for processing are used to estimate the impacts of changes. On the recreational side, a charter operator budget and recreational fisherman destination expenditures (Figure A2) provide the basic data. The individual expenditure categories are used to estimate the total community income impacts.

Total local and statewide personal income impacts for some of the major species harvested in the Columbia River are shown in Figure A3. For example, for gillnet caught spring chinook salmon (Figure A3), the landed price is $3.25 per pound. The yield on this dressed fish is 80 percent. The sales price is $5.00 per pound. The coastal community income received from this one pound is $4.40; the rest of the state receives another $1.35. The total state income thus generated by this one pound of salmon harvested and processed in Oregon therefore is $5.75. Note that these are income impacts for representative ex-vessel prices. The community economic impact depends on several factors. The most important factors are listed in Figure A4.

Figure A5 provides estimates of the economic contributions to Oregon personal income associated with recreationally fished ocean salmon. Several factors affect this personal income generated by recreational salmon fishing. The main factors are: means of fishing, expenditures patterns, and success ratios (Figure A6).

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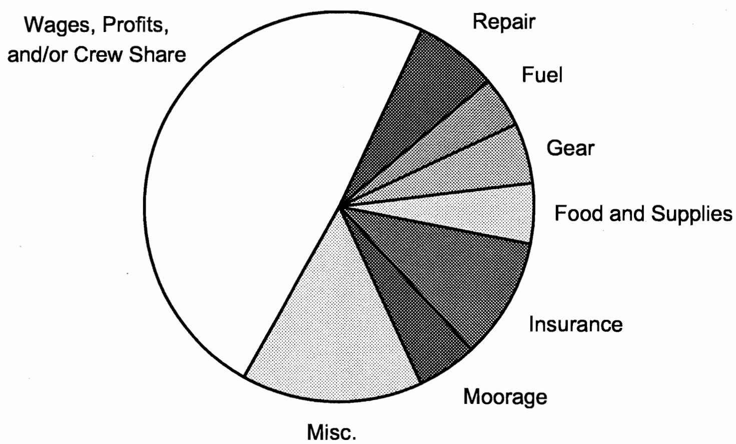
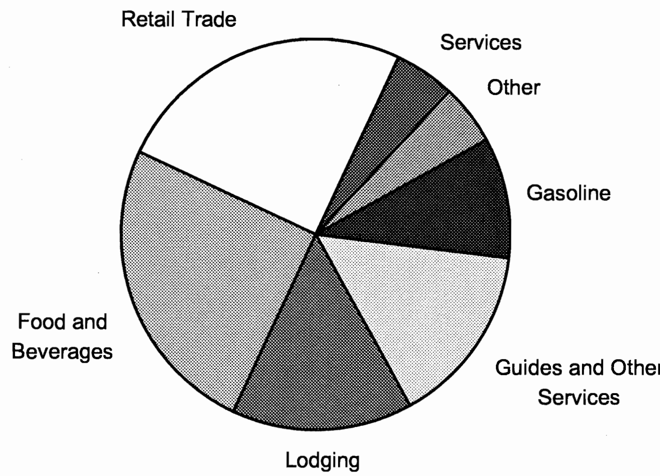
11. The commercial fisheries data were developed by Hans Radtke and William Jensen in connection with a project to develop a fisheries economic assessment model for the West Coast Fisheries Development Foundation, 1986. The budgets for recreational charter boats and recreational private boat fishermen are developed from The Research Group (1991).

Figure A2
Commercial Fishing and Charter Boat Angler Expenditures

Commercial Fishing[1]

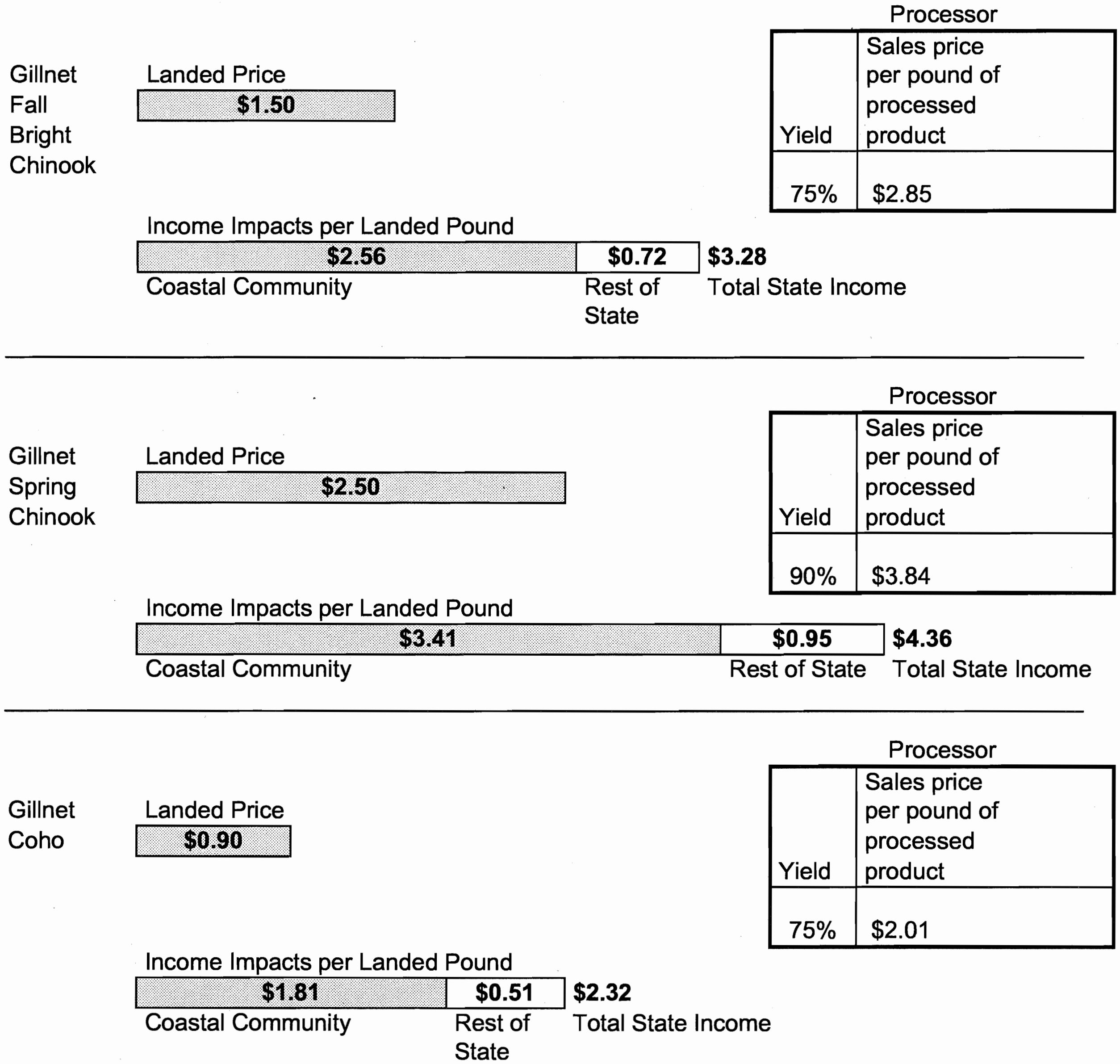


Charter Boat[2]



Sources: 1. Radtke and Jensen 1986.
2. The Research Group 1991.

Figure A3
Flow of Community and State Economic Impacts From Commercial Fishing in the Columbia



Source: Radtke and Davis 1995.

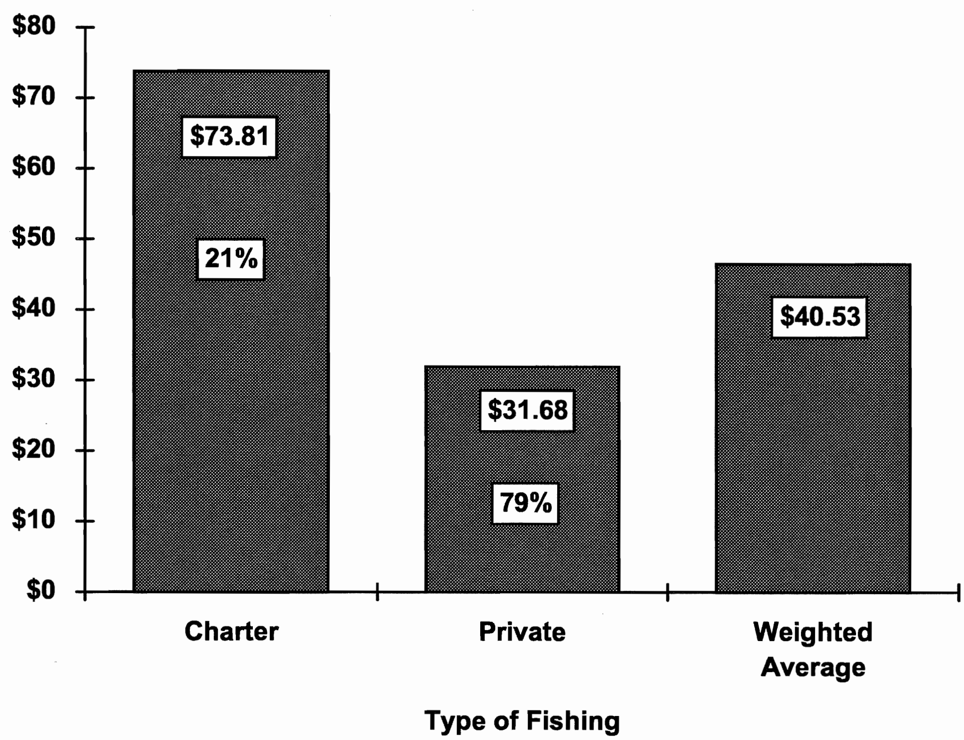
Figure A4
Factors Affecting Economic Contributions From Commercial Fishing

Commercial Fishing

- Landed price per pound
  Purchase patterns of fishing businesses
- Yield of product
- Type of Finished Product
- Sales price of processed product
  Purchase patterns of processors
- Spending patterns in local economy
- Size of local or regional economy
- Local money or nonlocal money

Source: Radtke and Davis 1994.

Figure A5
Typical Economic Impacts Per Day and Percent of Total Effort From Ocean Salmon Recreational Fishing



Notes: Weighted average based on recent years' average effort.
Source: Pacific Fishery Management Council 1994.

Figure A6
Factors Affecting Economic Contributions From Recreational Fishing

Recreational Fishing

- Modes of fishing
  Charter, private
- Expenditure patterns
- Success Ratio
  Average fish per day
- Spending patterns in local economy
- Size of local or regional economy
- Local money or nonlocal money

Source: Radtke and Davis 1994.

Calculating the Present Value of the Fishery Income Stream

Any periodic income stream is referred to as an "annuity." Calculating the present value of any ordinary annuity (one where the periodic payment stays the same) is a relatively straightforward equation as follows:

$$\text{Present value of an ordinary annuity} = \text{AMT}\left[\frac{1-\dfrac{1}{(1+r)^N}}{r}\right]$$

where r = the discount rate assumed;
N = the number of periods the annuity is paid out over; and,
AMT = the amount of the typical annuity payment

Nowadays, of course, electronic calculators compute these functions quickly and easily.

Appendix B
Columbia River Commercial Landings of Chinook, Coho, Sockeye, Chum and Steelhead Since 1866
by Number of Fish, Estimated Total Pounds, Ex-vessel Values and Economic Contributions

Date	Chinook	Total Pounds	Total ex-vessel value $	State level income Impact $	Coho	Total Pounds	Total ex-vessel value $	State level income Impact $	Sockeye	Total Pounds	Total ex-vessel value $	State level income Impact $	Chum	Total Pounds	Total ex-vessel value $	State level income Impact $	Steelhead	Total Pounds	Total ex-vessel value $	State level income Impact $	Total	Total Pounds	Total ex-vessel value $	State level income Impact $
1866	15	300	975	1725																	15	300	975	1,725
1867	66	1,320	4,290	7,590																	66	1,320	4,290	7,590
1868	102	2,040	6,630	11,730																	102	2,040	6,630	11,730
1869	367	7,340	23,855	42,205																	367	7,340	23,855	42,205
1870	550	11,000	35,750	63,250																	550	11,000	35,750	63,250
1871	733	14,660	47,645	84,295																	733	14,660	47,645	84,295
1872	916	18,320	59,540	105,340																	916	18,320	59,540	105,340
1873	916	18,320	59,540	105,340																	916	18,320	59,540	105,340
1874	1,283	25,660	83,395	147,545																	1,283	25,660	83,395	147,545
1875	1,375	27,500	89,375	158,125																	1,375	27,500	89,375	158,125
1876	1,650	33,000	107,250	189,750																	1,650	33,000	107,250	189,750
1877	1,393	27,860	90,545	160,195																	1,393	27,860	90,545	160,195
1888	1,686	33,720	109,590	193,890																	1,686	33,720	109,590	193,890
1889	1,760	35,200	114,400	202,400																	1,760	35,200	114,400	202,400
1880	1,943	38,860	126,295	223,445																	1,943	38,860	126,295	223,445
1881	2,016	40,320	131,040	231,840																	2,016	40,320	131,040	231,840
1882	1,984	39,680	128,960	228,160																	1,984	39,680	128,960	228,160
1883	2,307	46,140	149,955	265,305																	2,307	46,140	149,955	265,305
1884	2,273	45,460	147,745	261,395																	2,273	45,460	147,745	261,395
1885	2,030	40,600	131,950	233,450																	2,030	40,600	131,950	233,450
1886	1,644	32,880	106,860	189,060																	1,644	32,880	106,860	189,060
1887	1,305	26,100	84,825	150,075																	1,305	26,100	84,825	150,075
1888	1,365	27,300	88,725	156,975																	1,365	27,300	88,725	156,975
1889	978	19,560	63,570	112,470					348	1,218	2,436	4567.5					236	2,006	1,204	3,511	1,562	22,784	67,210	120,548
1890	1,230	24,600	79,950	141,450					1,120	3,920	7,840	14,700					399	3,392	2,035	5,935	2,749	31,912	89,825	162,085
1891	1,297	25,940	84,305	155,640					303	1,061	2,121	3,712					275	2,750	1,650	4,813	1,875	29,751	88,076	164,165
1892	1,262	25,240	82,030	145,130	32	288	288	634	1,300	4,550	9,100	17,063					674	5,729	3,437	10,026	3,268	35,807	94,855	172,852
1893	1,059	21,180	68,835	121,785	221	1,989	1,989	4,376	595	2,083	4,165	7,809	13	156	94	273	608	5,168	3,101	9,044	2,496	30,576	78,183	143,287
1894	1,287	25,740	83,655	148,005	325	2,925	2,925	6,435	856	2,996	5,992	11,235	0	0	0	0	488	4,148	2,489	7,259	2,956	35,809	95,061	172,934
1895	1,631	32,620	106,015	187,565	758	6,822	6,822	15,008	352	1,232	2,464	4,620	126	1,512	907	2,646	463	3,936	2,361	6,887	3,330	46,122	118,570	216,727
1896	1,360	27,200	88,400	156,400	335	3,015	3,015	6,633	332	1,162	2,324	4,358	0	0	0	0	463	3,936	2,361	6,887	2,490	35,313	96,100	174,278
1897	1,610	32,200	104,650	185,150	463	4,167	4,167	9,167	253	886	1,771	3,321	0	0	0	0	430	3,655	2,193	6,396	2,756	40,908	112,781	204,034
1898	1,250	25,000	81,250	143,750	498	4,482	4,482	9,860	1,303	4,561	9,121	17,102	0	0	0	0	245	2,083	1,250	3,644	3,296	36,125	96,103	174,357
1899	1,012	20,240	65,780	116,380	225	2,025	2,025	4,455	468	1,638	3,276	6,143	63	756	454	1,323	112	952	571	1,666	1,880	25,611	72,106	129,967
1900	1,037	20,740	67,405	119,255	341	3,069	3,069	6,752	257	900	1,799	3,373	99	1,188	713	2,079	192	1,632	979	2,856	1,926	27,529	73,965	134,315
1901	1,037	20,740	67,405	119,255	341	3,069	3,069	6,752	257	900	1,799	3,373	99	1,188	713	2,079	192	1,632	979	2,856	1,926	27,529	73,965	134,315
1902	1,242	24,840	80,730	142,830	80	720	720	1,584	333	1,166	2,331	4,371	58	696	418	1,218	80	680	408	1,190	1,793	28,102	84,607	151,193
1903	1,505	30,100	97,825	173,075	93	837	837	1,841	164	574	1,148	2,153	56	672	403	1,176	66	561	337	982	1,884	32,744	100,550	179,227
1904	1,713	34,260	111,345	196,995	238	2,142	2,142	4,712	252	882	1,764	3,308	115	1,380	828	2,415	92	782	469	1,369	2,410	39,446	116,548	208,798
1905	1,781	35,620	115,765	204,815	204	1,836	1,836	4,039	152	532	1,064	1,995	144	1,728	1,037	3,024	92	782	469	1,369	2,373	40,498	120,171	215,242
1906	1,616	32,320	105,040	185,840	315	2,835	2,835	6,237	153	536	1,071	2,008	155	1,860	1,116	3,255	61	519	311	907	2,300	38,069	110,373	198,248
1907	1,307	26,140	84,955	150,305	242	2,178	2,178	4,792	107	375	749	1,404	126	1,512	907	2,646	55	468	281	818	1,837	30,672	89,070	159,965
1908	1,064	21,280	69,160	122,360	239	2,151	2,151	4,732	168	588	1,176	2,205	94	1,128	677	1,974	100	850	510	1,488	1,665	25,997	73,674	132,759
1909	923	18,460	59,995	106,145	321	2,889	2,889	6,356	490	1,715	3,430	6,431	137	1,644	986	2,877	161	1,369	821	2,395	2,032	26,077	68,122	124,204
1910	1,365	27,300	88,725	156,975	524	4,716	4,716	10,375	122	427	854	1,601	371	4,452	2,671	7,791	51	434	260	759	2,433	37,329	97,226	177,501
1911	1,973	39,460	128,245	226,895	604	5,436	5,436	11,959	117	410	819	1,536	298	3,576	2,146	6,258	80	680	408	1,190	3,072	49,562	137,054	247,838
1912	1,153	23,060	74,945	132,595	242	2,178	2,178	4,792	160	560	1,120	2,100	104	1,248	749	2,184	294	2,499	1,499	4,373	1,953	29,545	80,491	146,044
1913	1,045	20,900	67,925	120,175	312	2,808	2,808	6,178	218	763	1,526	2,861	74	888	533	1,554	297	2,525	1,515	4,418	1,946	27,884	74,307	135,186
1914	1,370	27,400	89,050	157,550	531	4,779	4,779	10,514	690	2,415	4,830	9,056	275	3,300	1,980	5,775	261	2,219	1,331	3,882	3,127	40,113	101,970	186,777
1915	1,732	34,640	112,580	199,180	254	2,286	2,286	5,029	107	375	749	1,404	483	5,796	3,478	10,143	368	3,128	1,877	5,474	2,944	46,225	120,969	221,231
1916	1,725	34,500	112,125	198,375	396	3,564	3,564	7,841	74	259	518	971	434	5,208	3,125	9,114	217	1,845	1,107	3,228	2,846	45,376	120,439	219,529
1917	1,591	31,820	103,415	182,965	489	4,401	4,401	9,682	156	546	1,092	2,048	299	3,588	2,153	6,279	306	2,601	1,561	4,552	2,841	42,956	112,621	205,525
1918	1,577	31,540	102,505	181,355	747	6,723	6,723	14,791	739	2,587	5,173	9,699	166	1,992	1,195	3,486	414	3,519	2,111	6,158	3,643	46,361	117,708	215,489
1919	1,635	32,700	106,275	188,025	690	6,210	6,210	13,662	142	497	994	1,864	421	5,052	3,031	8,841	260	2,210	1,326	3,868	3,148	46,669	117,836	216,259
1920	1,676	33,520	108,940	192,740	206	1,854	1,854	4,079	51	179	357	669	105	1,260	756	2,205	160	1,360	816	2,380	2,198	38,173	112,723	202,073
1921	1,162	23,240	75,530	133,630	261	2,349	2,349	5,168	118	413	826	1,549	27	324	194	567	140	1,190	714	2,083	1,708	27,516	79,613	142,996
1922	966	19,320	62,790	111,090	688	6,192	6,192	13,622	601	2,104	4,207	7,888	49	588	353	1,029	296	2,516	1,510	4,403	2,600	30,720	75,051	138,033
1923	1,163	23,260	75,595	133,745	779	7,011	7,011	15,424	749	2,622	5,243	9,831	142	1,704	1,022	2,982	368	3,128	1,877	5,474	3,201	37,725	90,748	167,456
1924	1,206	24,120	78,390	138,690	872	7,848	7,848	17,266	144	504	1,008	1,890	322	3,864	2,318	6,762	437	3,715	2,229	6,500	2,981	40,051	91,793	171,108
1925	1,437	28,740	93,405	165,255	888	7,992	7,992	17,582	110	385	770	1,444	311	3,732	2,239	6,531	398	3,383	2,030	5,920	3,144	44,232	106,436	196,732
1926	1,145	22,900	74,425	131,675	739	6,651	6,651	14,632	425	1,488	2,975	5,578	183	2,196	1,318	3,843	526	4,471	2,683	7,824	3,018	37,706	88,051	163,553
1927	1,294	25,880	84,110	148,810	583	5,247	5,247	11,543	134	469	938	1,759	382	4,584	2,750	8,022	431	3,664	2,198	6,411	2,824	39,844	95,244	176,545
1928	978	19,560	63,570	112,470	416	3,744	3,744	8,237	94	329	658	1,234	697	8,364	5,018	14,637	296	2,516	1,510	4,403	2,481	34,513	74,500	140,981
1929	978	19,560	63,570	112,470	750	6,750	6,750	14,850	197	690	1,379	2,586	305	3,660	2,196	6,405	393	3,341	2,004	5,846	2,623	34,000	75,899	142,157
1930	1,082	21,640	70,330	124,430	865	7,785	7,785	17,127	192	672	1,344	2,520	63	756	454	1,323	329	2,797	1,678	4,894	2,531	33,650	81,591	150,294
1931	1,152	23,040	57,600	103,680	304	2,736	2,736	6,019	81	284	567	1,063	20	240	144	420	291	2,474	1,484	4,329	1,848	28,773	62,531	115,511
1932	863	17,260	43,150	77,670	458	4,122	4,122	9,068	55	193	385	722	96	1,152	691	2,016	196	1,666	1,000	2,916	1,668	24,393	49,348	92,392

continued

Date	Chinook	Total Pounds	Total ex-vessel value $	State level income impact $	Coho	Total Pounds	Total ex-vessel value $	State level income impact $	Sockeye	Total Pounds	Total ex-vessel value $	State level income impact $	Chum	Total Pounds	Total ex-vessel value $	State level income impact $	Steelhead	Total Pounds	Total ex-vessel value $	State level income impact $	Total	Total Pounds	Total ex-vessel value $	State level income impact $
1933	1,053	21,060	52,650	94,770	302	2,718	2,718	5,980	135	473	945	1,772	136	1,632	979	2,856	268	2,278	1,367	3,987	1,894	28,161	58,659	109,364
1934	1,013	20,260	50,650	91,170	534	4,806	4,806	10,573	134	469	938	1,759	136	1,632	979	2,856	263	2,236	1,341	3,912	2,080	29,403	58,715	110,270
1935	820	16,400	41,000	73,800	300	2,700	2,700	5,940	13	46	91	171	66	792	475	1,386	242	2,057	1,234	3,600	1,441	21,995	45,500	84,896
1936	860	17,200	43,000	77,400	185	1,665	1,665	3,663	87	305	609	1,142	94	1,128	677	1,974	316	2,686	1,612	4,701	1,542	22,984	47,562	88,879
1937	1,006	20,120	50,300	90,540	206	1,854	1,854	4,079	96	336	672	1,260	157	1,884	1,130	3,297	265	2,253	1,352	3,942	1,730	26,447	55,308	103,118
1938	669	13,380	33,450	60,210	257	2,313	2,313	5,089	122	427	854	1,601	157	1,884	1,130	3,297	242	2,057	1,234	3,600	1,447	20,061	38,982	73,797
1939	728	14,560	36,400	65,520	171	1,539	1,539	3,386	78	273	546	1,024	96	1,152	691	2,016	197	1,675	1,005	2,930	1,270	19,199	40,181	74,876
1940	729	14,580	36,450	65,610	155	1,395	1,395	3,069	104	364	728	1,365	103	1,236	742	2,163	387	3,290	1,974	5,757	1,478	20,865	41,288	77,964
1941	1,253	25,060	62,650	112,770	117	1,053	1,053	2,317	145	508	1,015	1,903	340	4,080	2,448	7,140	293	2,491	1,494	4,358	2,148	33,191	68,660	128,488
1942	1,007	20,140	50,350	90,630	72	648	648	1,426	55	193	385	722	426	5,112	3,067	8,946	200	1,700	1,020	2,975	1,760	27,793	55,470	104,698
1943	616	12,320	30,800	55,440	79	711	711	1,564	42	147	294	551	79	948	569	1,659	167	1,420	852	2,484	983	15,546	33,226	61,699
1944	758	15,160	37,900	68,220	171	1,539	1,539	3,386	15	53	105	197	23	276	166	483	180	1,530	918	2,678	1,147	18,558	40,628	74,963
1945	699	13,980	34,950	62,910	204	1,836	1,836	4,039	3	11	21	39	48	576	346	1,008	203	1,726	1,035	3,020	1,157	18,128	38,188	71,016
1946	770	15,400	38,500	69,300	118	1,062	1,062	2,336	37	130	259	486	73	876	526	1,533	183	1,556	933	2,722	1,181	19,023	41,280	76,377
1947	933	18,660	46,650	83,970	167	1,503	1,503	3,307	206	721	1,442	2,704	41	492	295	861	179	1,522	913	2,663	1,526	22,898	50,803	93,504
1948	935	18,700	46,750	84,150	131	1,179	1,179	2,594	28	98	196	368	86	1,032	619	1,806	157	1,335	801	2,335	1,337	22,344	49,545	91,253
1949	581	11,620	29,050	52,290	100	900	900	1,980	7	25	49	92	45	540	324	945	88	748	449	1,309	821	13,833	30,772	56,616
1950	562	11,240	28,100	50,580	117	1,053	1,053	2,317	49	172	343	643	58	696	418	1,218	101	859	515	1,502	887	14,019	30,429	56,260
1951	541	10,820	27,050	48,690	108	972	972	2,138	49	172	343	643	44	528	317	924	154	1,309	785	2,291	896	13,801	29,467	54,686
1952	392	7,840	19,600	35,280	120	1,080	1,080	2,376	175	613	1,225	2,297	25	300	180	525	188	1,598	959	2,797	900	11,431	23,044	43,274
1953	376	7,520	18,800	33,840	52	468	468	1,030	42	147	294	551	20	240	144	420	225	1,913	1,148	3,347	715	10,288	20,854	39,188
1954	286	5,720	14,300	25,740	34	306	306	673	70	245	490	919	26	312	187	546	154	1,309	785	2,291	570	7,892	16,069	30,169
1955	463	9,260	23,150	41,670	69	621	621	1,366	57	200	399	748	10	120	72	210	162	1,377	826	2,410	761	11,578	25,068	46,404
1956	441	8,820	13,230	28,665	52	468	468	1,030	82	287	574	1,076	4	48	29	84	108	918	551	1,607	687	10,541	14,852	32,461
1957	319	6,380	9,570	20,735	46	414	414	911	69	242	483	906	3	36	22	63	98	833	500	1,458	535	7,905	10,988	24,072
1958	347	6,940	10,410	22,555	19	171	171	376	208	728	1,456	2,730	7	84	50	147	92	782	469	1,369	673	8,705	12,557	27,177
1959	248	4,960	7,440	16,120	15	135	135	297	183	641	1,281	2,402	4	48	29	84	108	918	551	1,607	558	6,702	9,436	20,509
1960	266	5,320	7,980	17,290	18	162	162	356	120	420	840	1,575	1	12	7	21	94	799	479	1,398	499	6,713	9,469	20,641
1961	254	5,080	7,620	16,510	38	342	342	752	40	140	280	525	1	12	7	21	100	850	510	1,488	433	6,424	8,759	19,296
1962	311	6,220	9,330	20,215	65	585	585	1,287	14	49	98	184	4	48	29	84	99	842	505	1,473	493	7,744	10,547	23,242
1963	251	5,020	7,530	16,315	65	585	585	1,287	14	49	98	184	1	12	7	21	117	995	597	1,740	448	6,661	8,817	19,547
1964	269	5,380	8,070	17,485	206	1,854	1,854	4,079	21	74	147	276	2	24	14	42	56	476	286	833	554	7,808	10,371	22,714
1965	336	6,720	10,080	21,840	235	2,115	2,115	4,653	6	21	42	79	1	12	7	21	64	544	326	952	642	9,412	12,571	27,545
1966	201	4,020	6,030	13,065	424	3,816	3,816	8,395	4	14	28	53	1	12	7	21	47	400	240	699	677	8,262	10,121	22,233
1967	263	5,260	7,890	17,095	382	3,438	3,438	7,564	56	196	392	735	1	12	7	21	50	425	255	744	752	9,331	11,982	26,158
1968	220	4,400	6,600	14,300	133	1,197	1,197	2,633	25	88	175	328	1	12	7	21	45	383	230	669	424	6,079	8,209	17,952
1969	318	6,360	9,540	20,670	198	1,782	1,782	3,920	26	91	182	341	1	12	7	21	48	408	245	714	591	8,653	11,756	25,667
1970	357	7,140	10,710	23,205	536	4,824	4,824	10,613	17	60	119	223	1	12	7	21	33	281	168	491	944	12,316	15,829	34,553
1971	332	6,640	9,960	21,580	277	2,493	2,493	5,485	76	266	532	998	1	12	7	21	51	434	260	759	737	9,845	13,252	28,842
1972	319	6,380	9,570	20,735	140	1,260	1,260	2,772	78	273	546	1,024	1	12	7	21	62	527	316	922	600	8,452	11,699	25,474
1973	454	9,080	13,620	29,510	195	1,755	1,755	3,861	4	14	28	53	1	12	7	21	53	451	270	788	707	11,312	15,681	34,233
1974	191	3,820	5,730	12,415	273	2,457	2,457	5,405	0	0	0	0	1	12	7	21	19	162	97	283	484	6,451	8,291	18,124
1975	323	6,460	9,690	20,995	162	1,458	1,458	3,208	0	0	0	0	1	12	7	21	7	60	36	104	493	7,990	11,191	24,328
1976	288	5,760	8,640	18,720	172	1,548	1,548	3,406	0	0	0	0	1	12	7	21	10	85	51	149	471	7,405	10,246	22,295
1977	256	5,120	7,680	16,640	40	360	360	792	0	0	0	0	0	0	0	0	35	298	179	521	331	5,778	8,219	17,953
1978	189	3,780	5,670	12,285	136	1,224	1,224	2,693	0	0	0	0	2	24	14	42	20	170	102	298	347	5,198	7,010	15,317
1979	171	3,420	5,130	11,115	132	1,188	1,188	2,614	0	0	0	0	0	0	0	0	9	77	46	134	312	4,685	6,364	13,862
1980	150	3,000	4,500	9,750	150	1,350	1,350	2,970	0	0	0	0	0	0	0	0	7	60	36	104	307	4,410	5,886	12,824
1981	95	1,900	2,850	6,175	62	558	558	1,228	0	0	0	0	1	12	7	21	10	85	51	149	168	2,555	3,466	7,572
1982	155	3,100	4,650	10,075	206	1,854	1,854	4,079	0	0	0	0	2	24	14	42	9	77	46	134	372	5,055	6,564	14,330
1983	58	1,160	1,740	3,770	7	63	63	139	2	7	14	26	0	0	0	0	19	162	97	283	86	1,392	1,914	4,217
1984	128	2,560	3,840	8,320	204	1,836	1,836	4,039	32	112	224	420	2	24	14	42	75	638	383	1,116	441	5,170	6,297	13,937
1985	151	3,020	4,530	9,815	195	1,755	1,755	3,861	81	284	567	1,063	1	12	7	21	86	731	439	1,279	514	5,802	7,298	16,039
1986	283	5,660	8,490	18,395	998	8,982	8,982	19,760	6	21	42	79	2	24	14	42	72	612	367	1,071	1,361	15,299	17,896	39,347
1987	484	9,680	14,520	31,460	170	1,530	1,530	3,366	68	238	476	893	1	12	7	21	79	672	403	1,175	802	12,132	16,936	36,915
1988	489	9,780	14,670	31,785	368	3,312	3,312	7,286	49	172	343	643	3	36	22	63	79	672	403	1,175	988	13,971	18,750	40,953
1989	275	5,500	8,250	17,875	392	3,528	3,528	7,762	0	0	0	0	1	12	7	21	61	519	311	907	729	9,559	12,096	26,565
1990	147	2,940	4,410	9,555	76	684	684	1,505	0	0	0	0	1	12	7	21	33	281	168	491	257	3,917	5,270	11,572
1991	107	2,140	3,210	6,955	416	3,744	3,744	8,237	0	0	0	0	0	0	0	0	37	315	189	550	560	6,199	7,143	15,742
1992	53	1,060	1,590	3,445	59	531	531	1,168	0	0	0	0	1	12	7	21	52	442	265	774	165	2,045	2,393	5,408
1993	51	1,020	1,530	3,315	37	333	333	733	0	0	0	0	0	0	0	0	28	238	143	417	116	1,591	2,006	4,464

Notes:

1. Economic contributions are in thousands of 1994 dollars and are measured as State level personal income impacts.

2. Number of fish harvested may not indicate the number of fish produced by the Columbia River system. In earlier years, some species were not harvested; in the late 1800's and early 1900's, there was overharvesting of several species and, since the early 1900's, salmon have been harvested in other parts of their range.

3. Total pounds were estimated using a common pounds per fish factor. The factors by species are:

a)	Chinook	20 lbs.
b)	Coho	9 lbs.
c)	Sockeye	3.5 lbs.
d)	Chum	12 lbs.
e)	Steelhead	8.5 lbs.

   The pounds per fish are a historical representative of the weight of the species in the Columbia River.

4. The ex-vessel values by species represent prices that may have been received for these fish if they had been harvested during the last few years (since 1990). For chinook, the composition of the species has changed from mostly spring and summer chinook (harvested by June) to mostly fall chinook. In order to represent these shifts in the composition, three separate price levels are used for chinook. The price factors used to report salmon harvested in the Columbia River are:

a1)	Chinook until 1930	3.25
a2)	Chinook from 1930 to 1955	2.50
a3)	Chinook since 1955	1.50
b)	Coho	1.00
c)	Sockeye	2.00
d)	Chum	0.60
e)	Steelhead	0.60

5. Income impacts are estimated at the State level. The amount that the harvesting and processing of these fish would contribute at today's prices, if they were marketed in fresh or frozen form, as whole fish. No added value processing, such as specialty packs, canning, or smoking are included in these estimates. The following are State level personal income impacts per pound used in these estimates.

a1)	Chinook until 1930	5.75
a2)	Chinook from 1930 to 1955	4.50
a3)	Chinook since 1955	3.25
b)	Coho	2.20
c)	Sockeye	3.75
d)	Chum	1.75
e)	Steelhead	1.75

Sources: Landing data are from Northwest Power Planning Council (1986), fish size and ex-vessel price are from ODFW (1995), and the State level personal income impacts per pound are from Radtke and Davis (1994).

Historical Columbia River Estimated State Income Impact

Figure B1a
Total Salmon and Steelhead

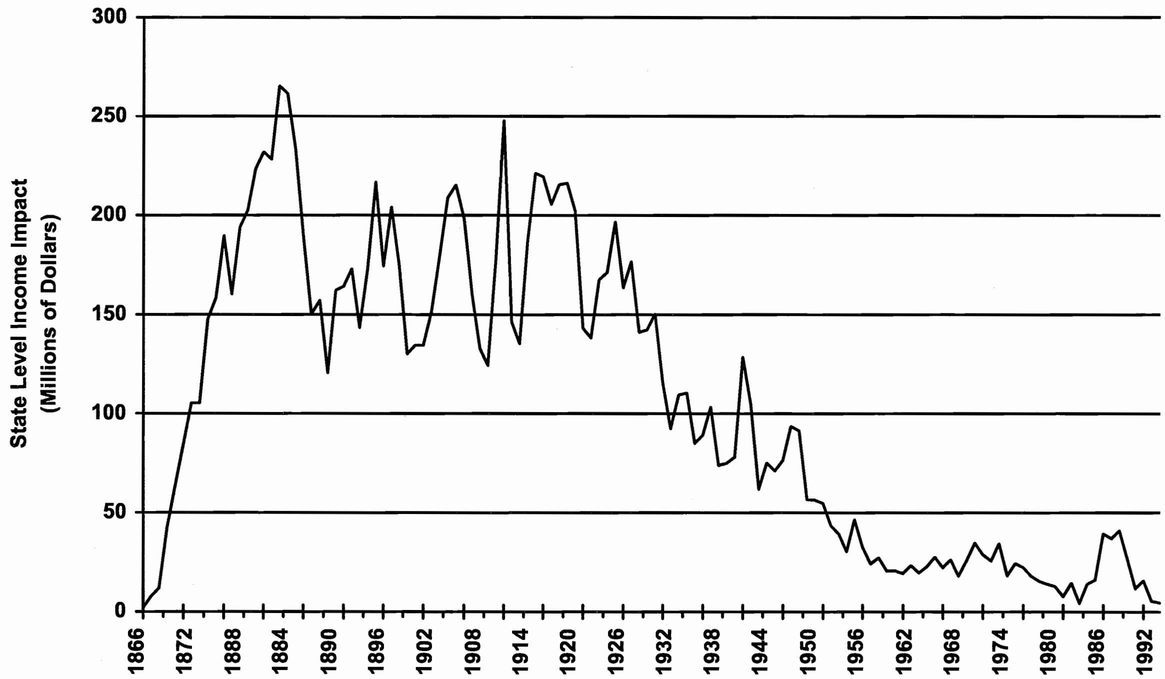
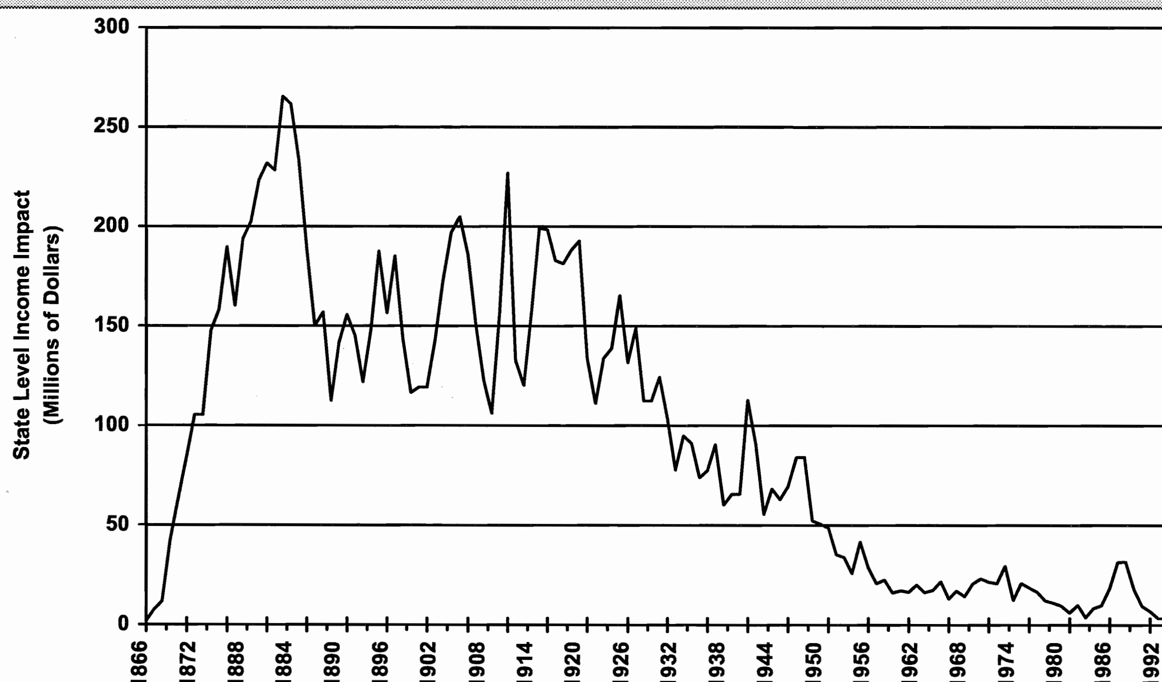


Figure B1b
Chinook



Historical Columbia River Estimated State Income Impact

Figure B1c
Coho

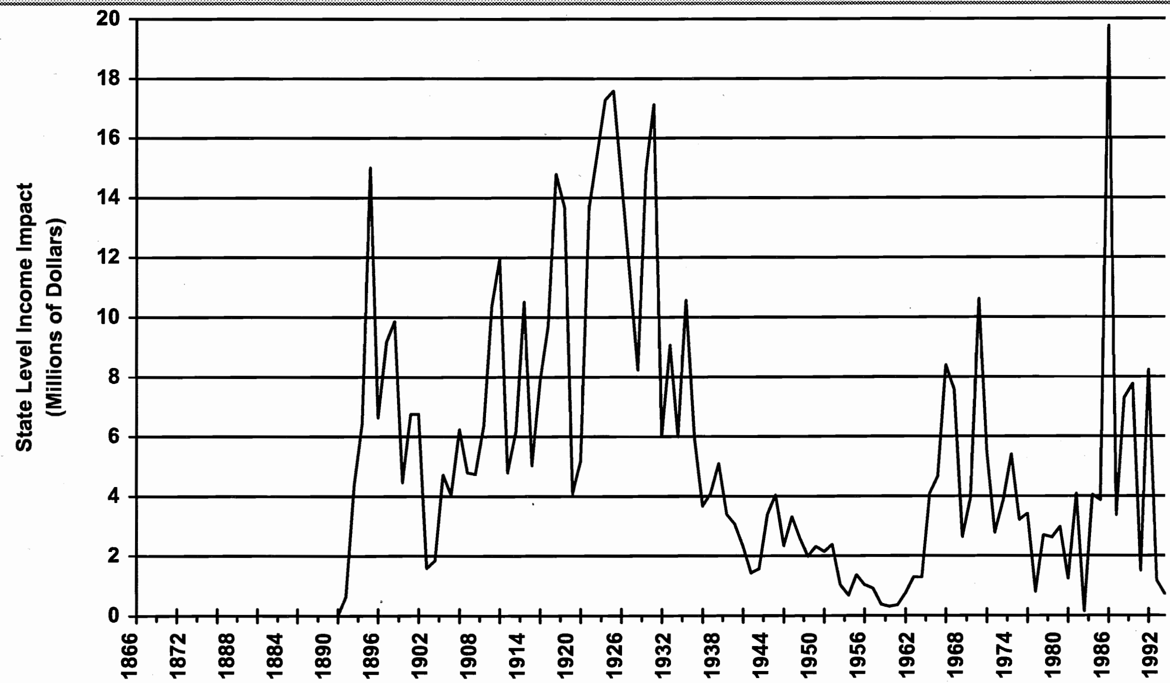
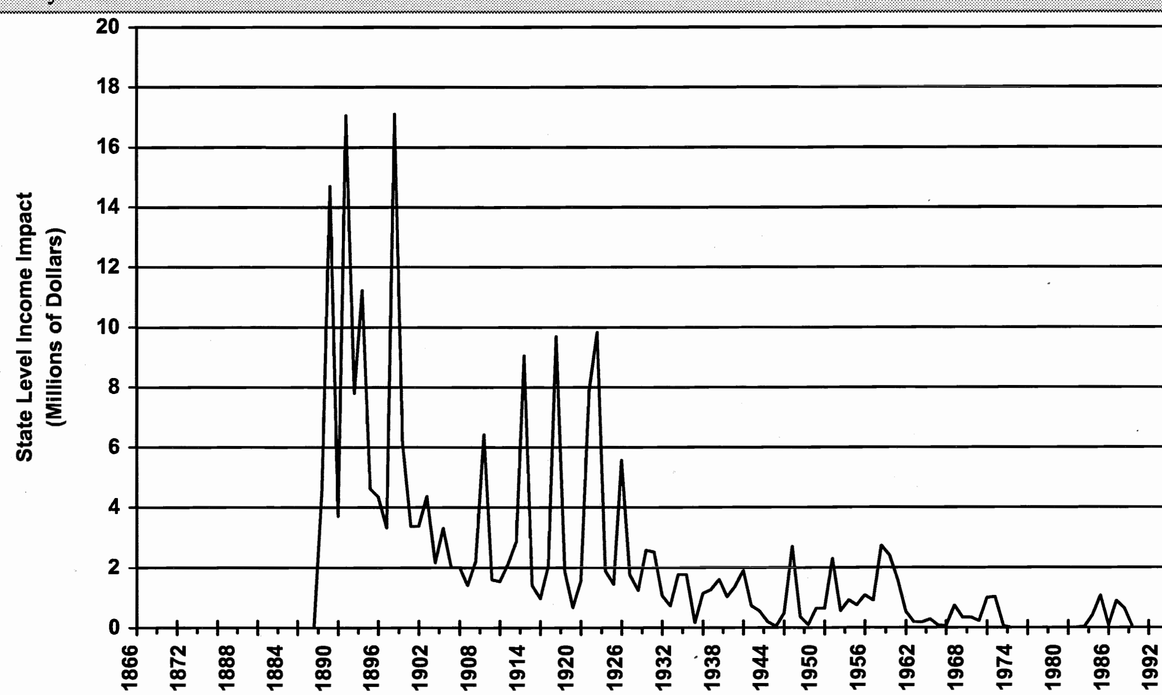


Figure B1d
Sockeye



Historical Columbia River Estimated State Income Impact

Figure B1e
Chum

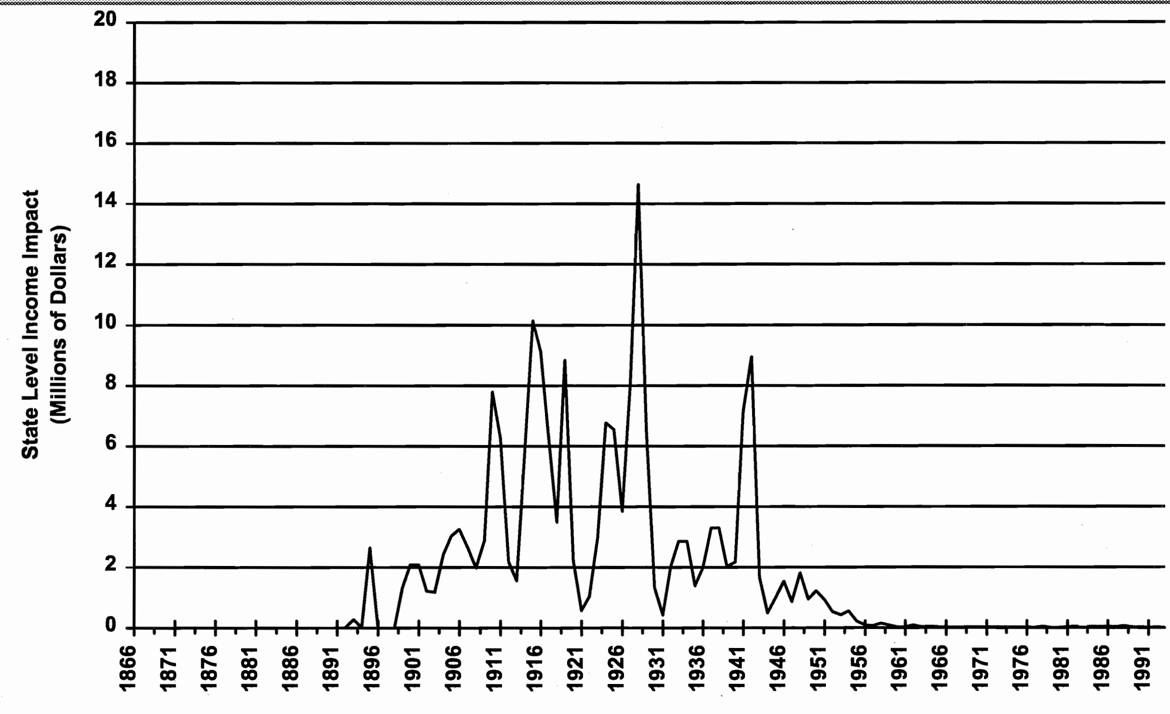
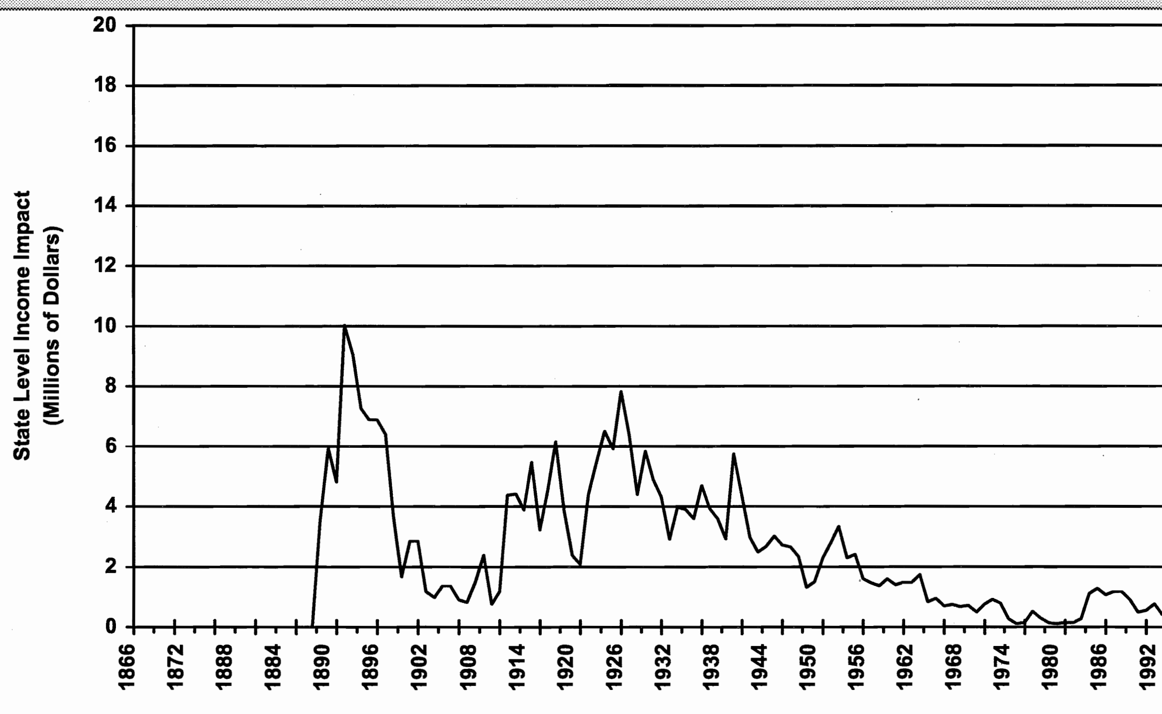


Figure B1f
Steelhead



Historical Columbia River Fish Landed

Figure B2a
Total Salmon and Steelhead

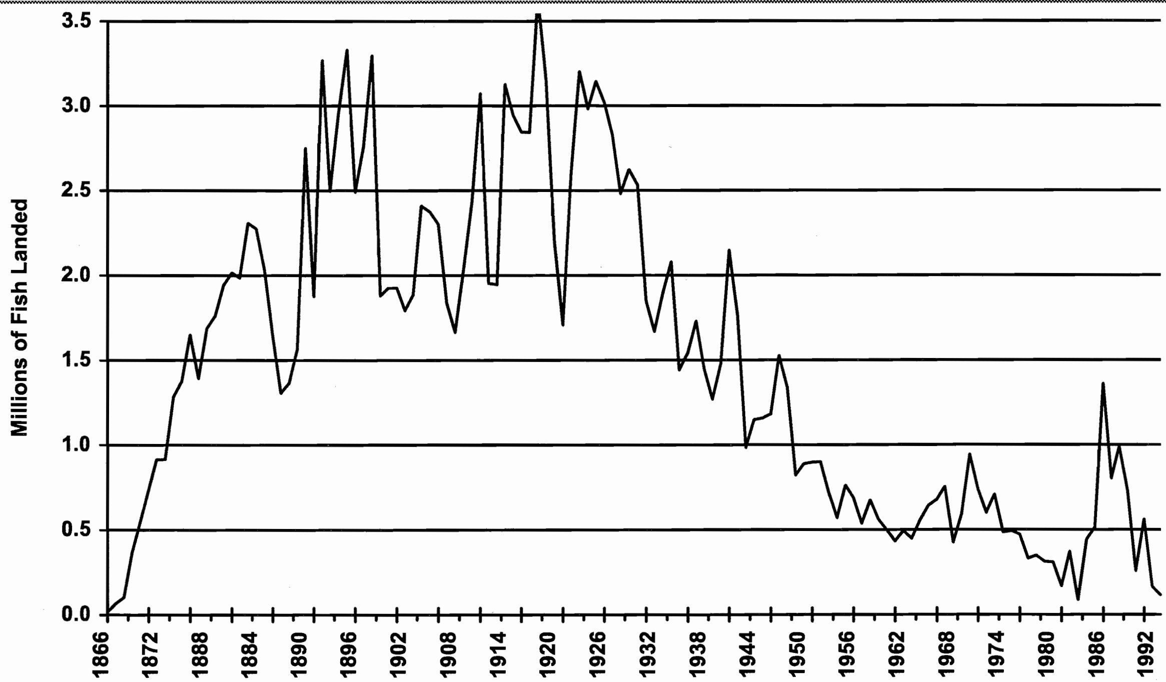
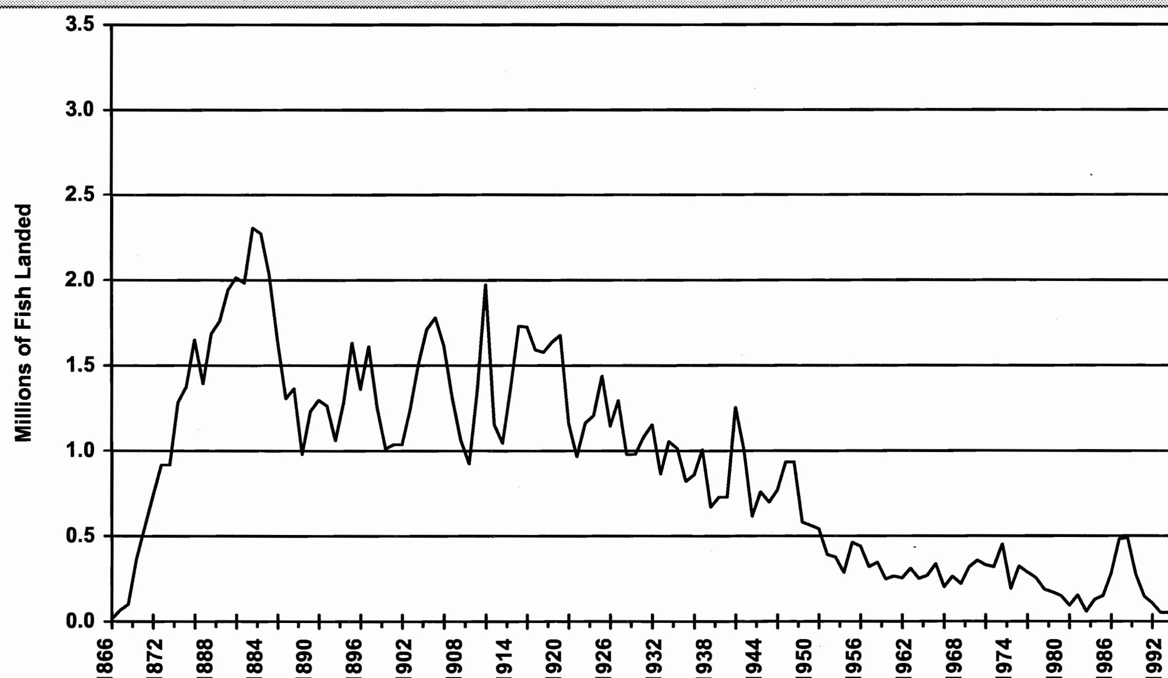


Figure B2b
Chinook



Historical Columbia River Fish Landed

Figure B2c
Coho

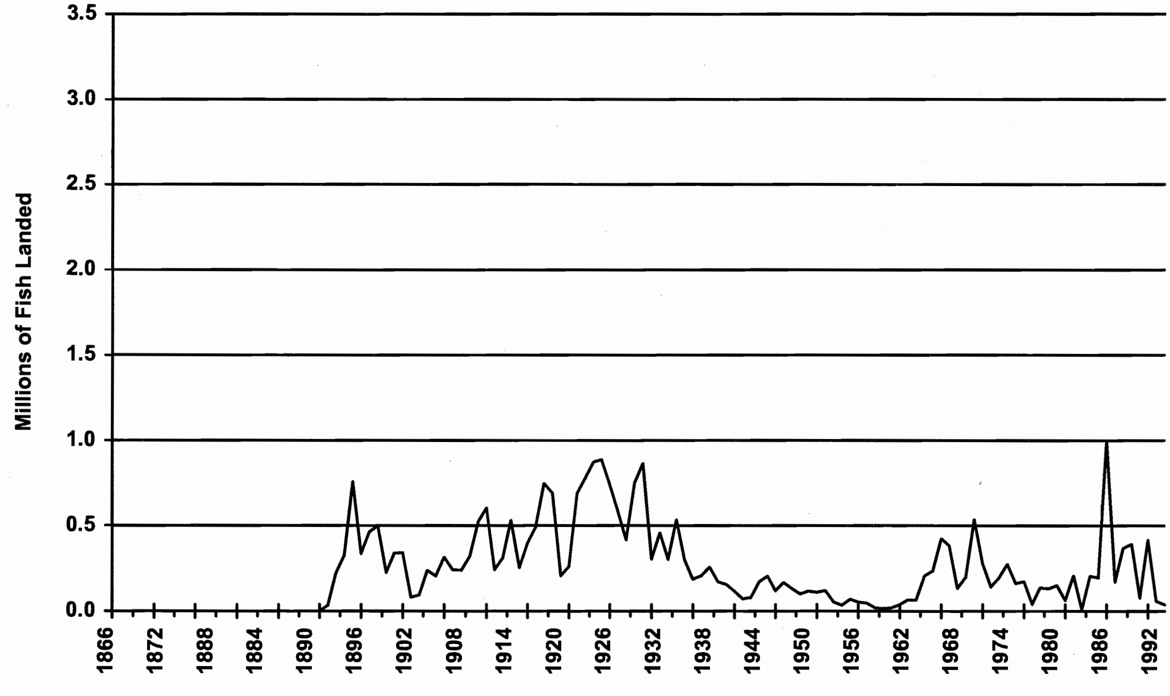
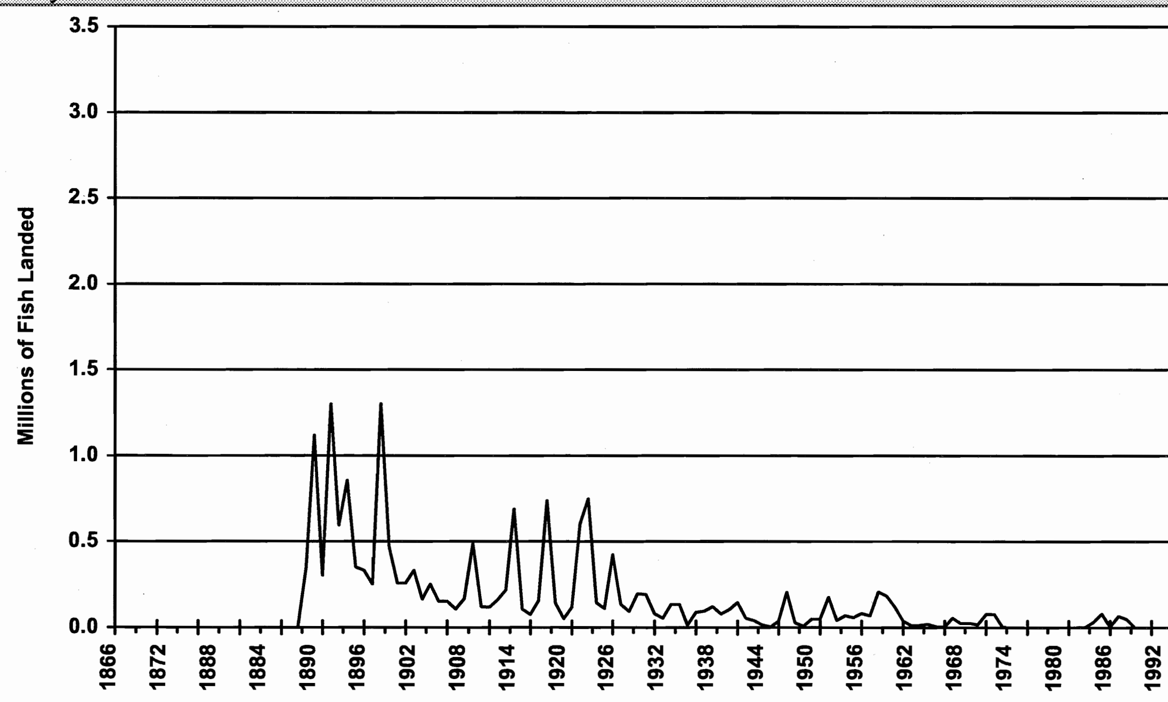


Figure B2d
Sockeye



Historical Columbia River Fish Landed

Figure B2e
Chum

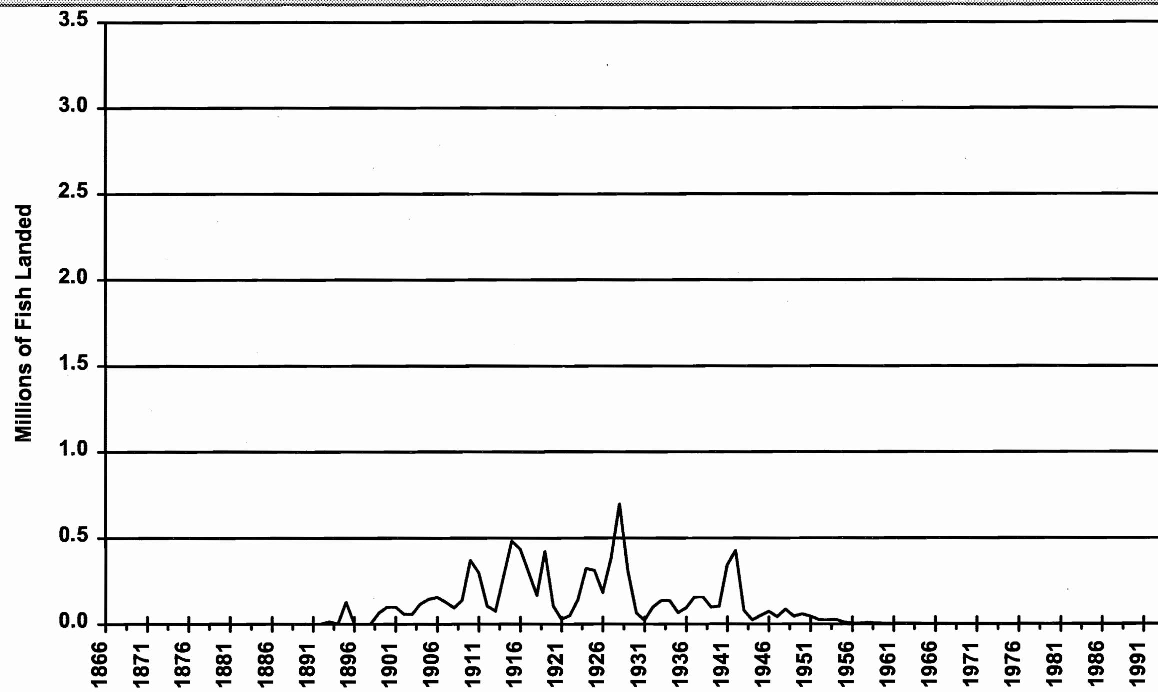
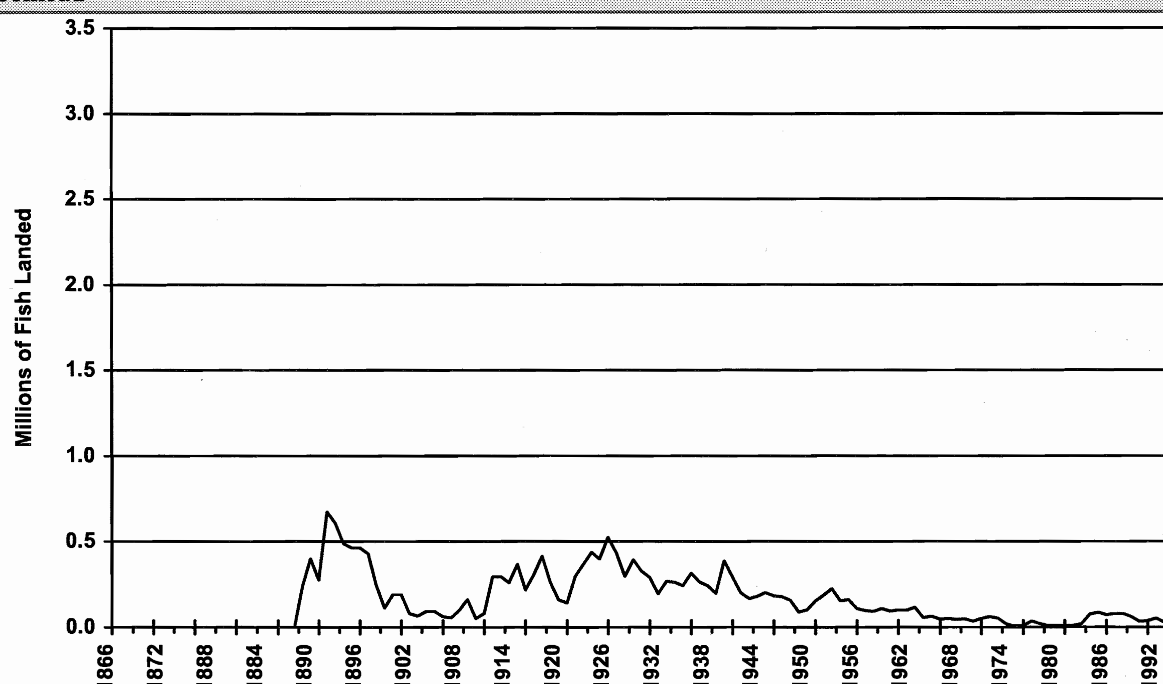


Figure B2f
Steelhead



Estimated Historical Columbia River Pounds Landed

Figure B3a
Total Salmon and Steelhead

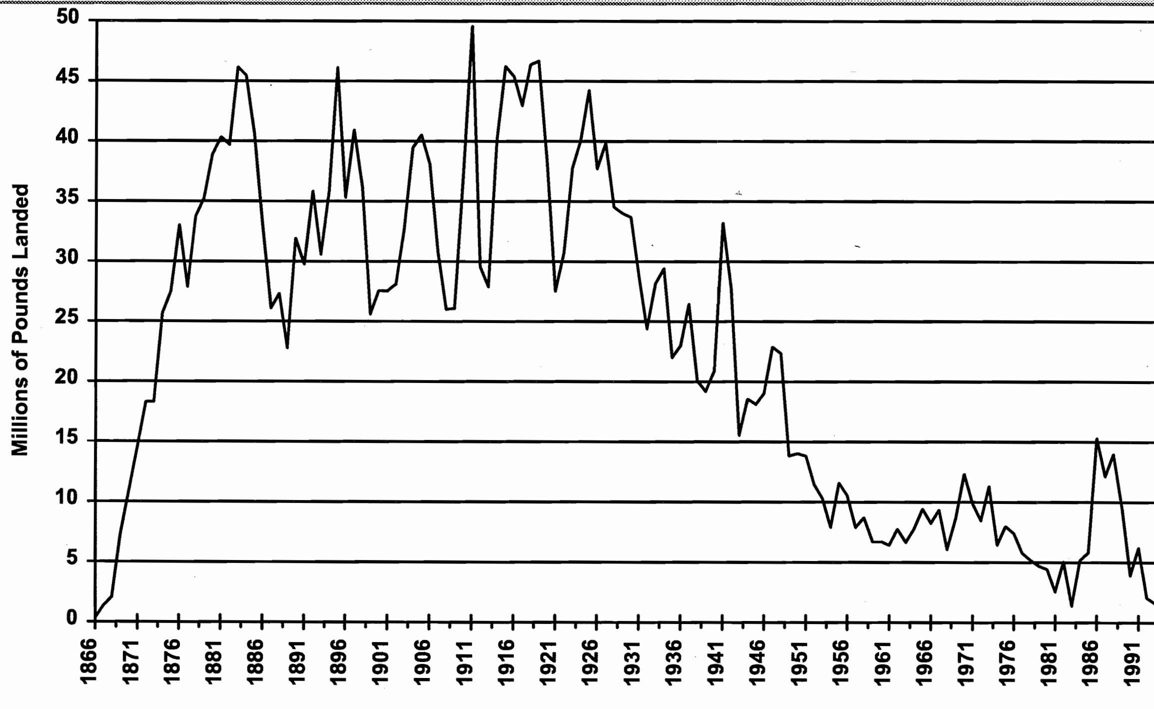
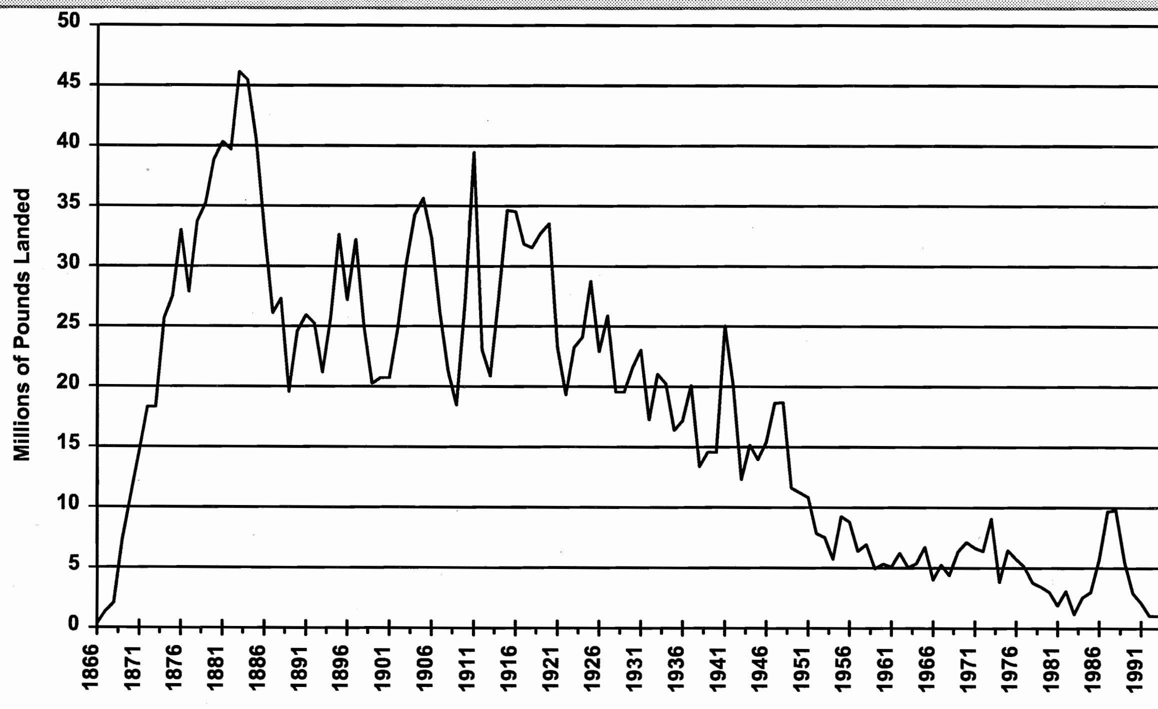


Figure B3b
Chinook



Estimated Historical Columbia River Pounds Landed

Figure B3c
Coho

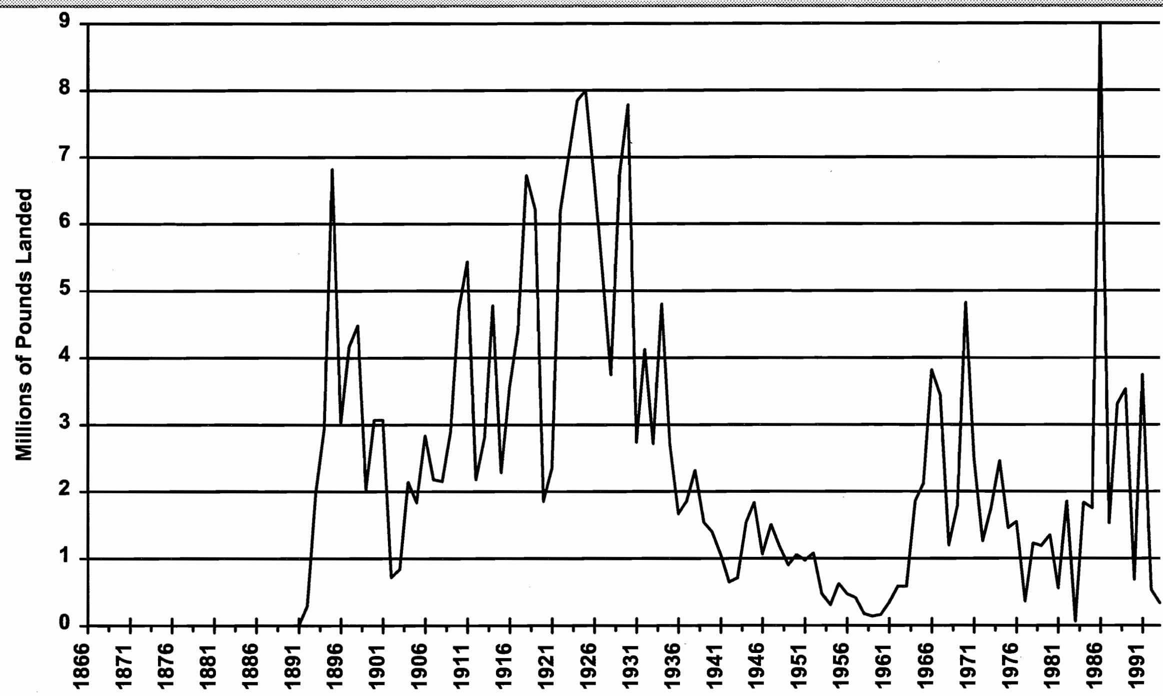
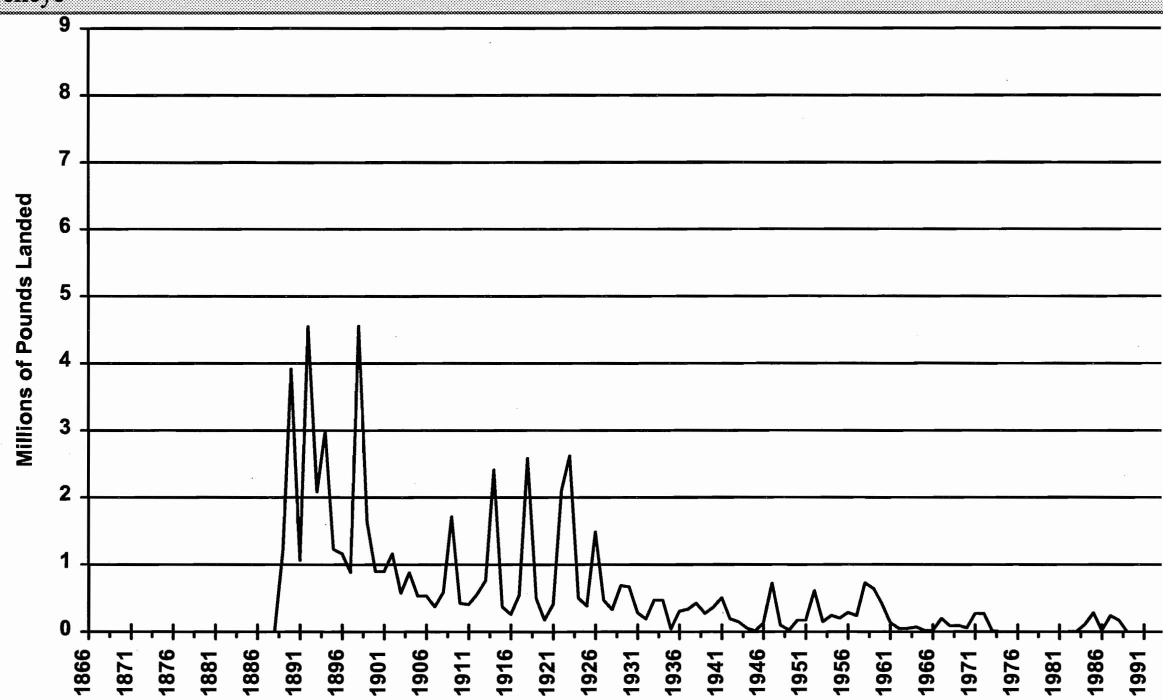


Figure B3d
Sockeye



Estimated Historical Columbia River Pounds Landed

Figure B3e
Chum

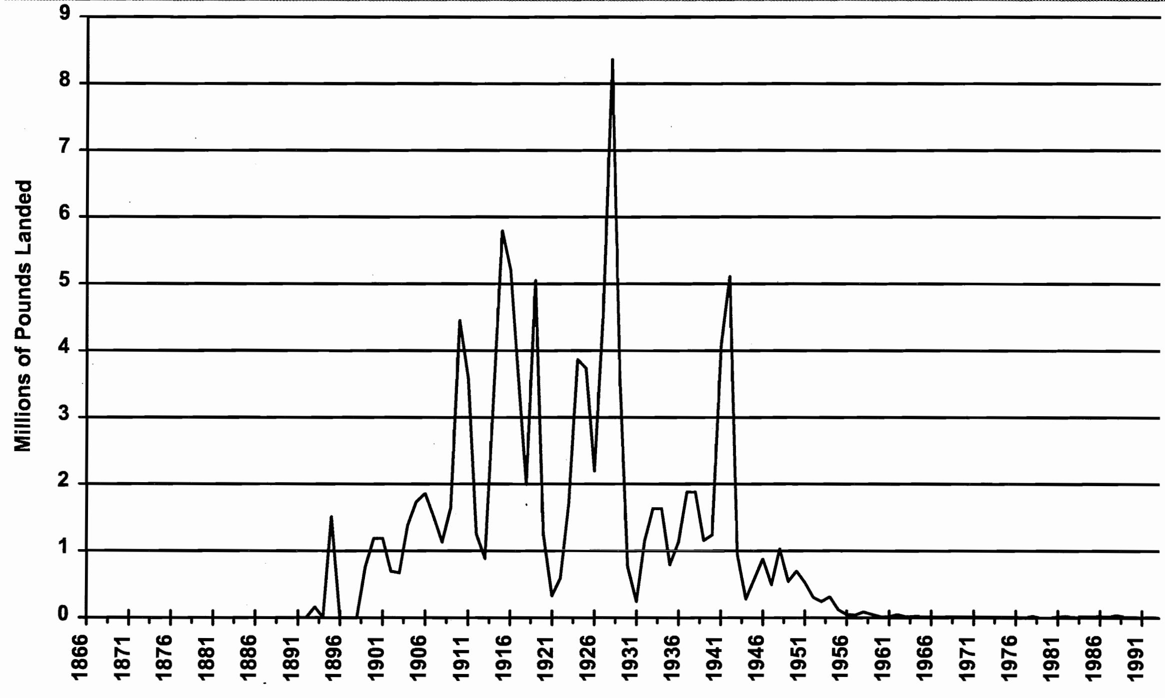
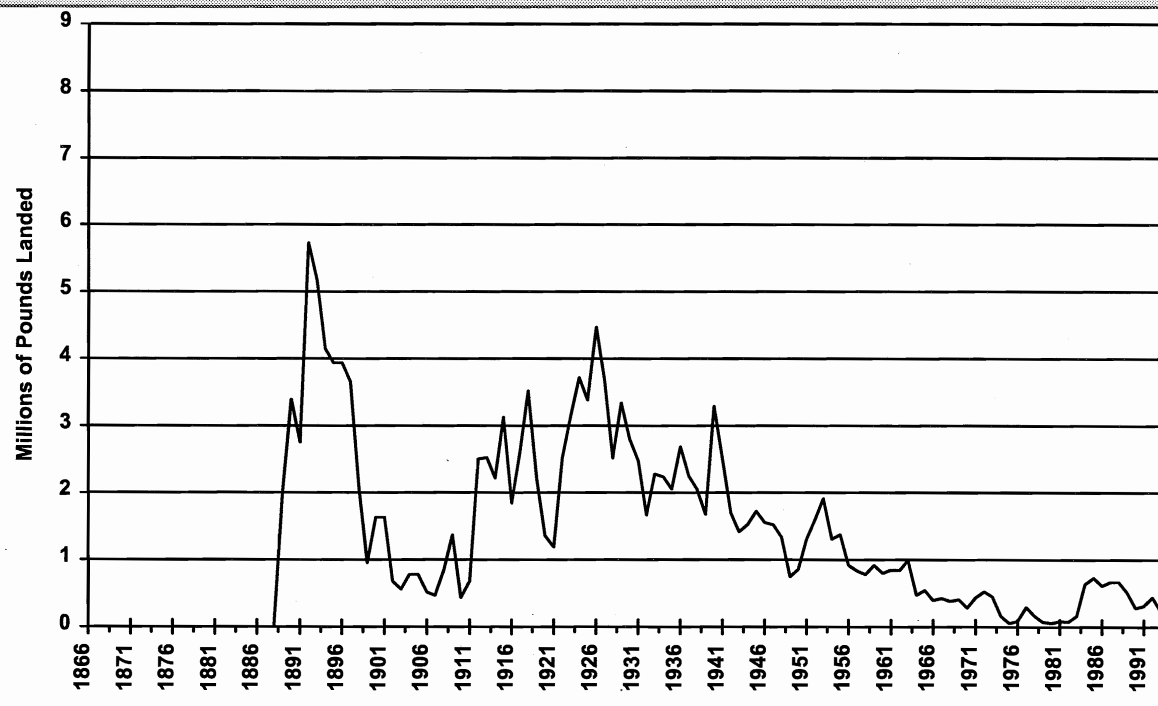


Figure B3f
Steelhead



Estimated Historical Columbia River Landed Ex-Vessel Values

Figure B4a
Total Salmon and Steelhead

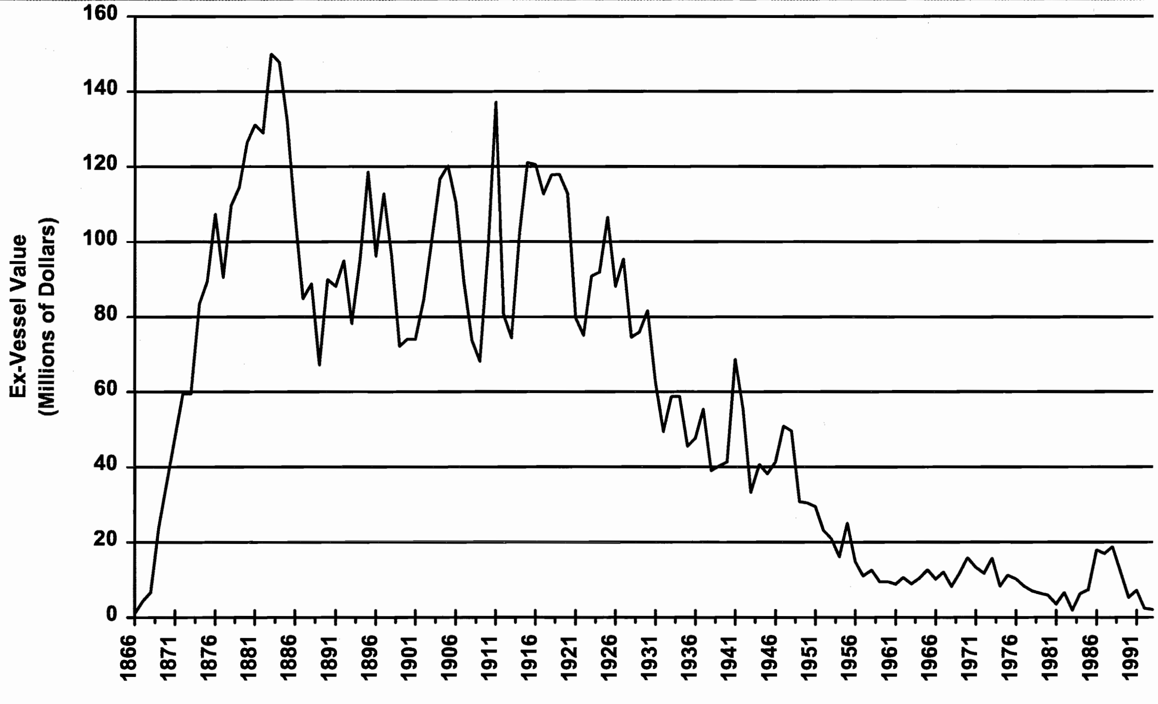
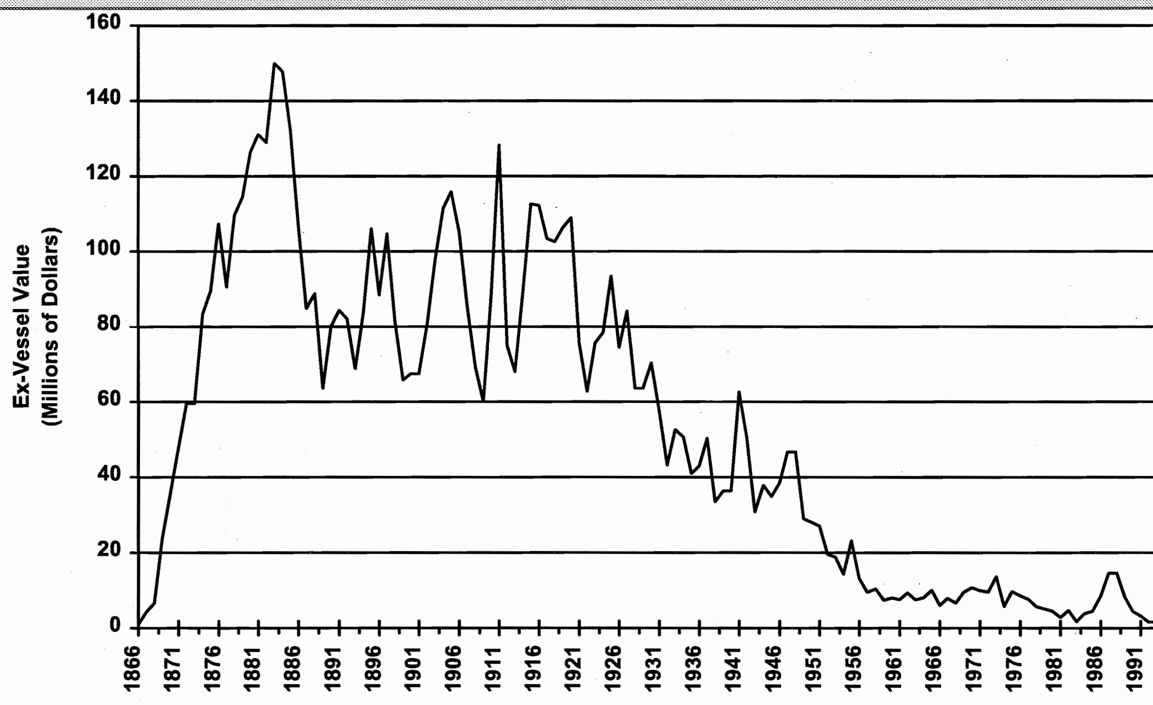


Figure B4b
Chinook



Estimated Historical Columbia River Landed Ex-Vessel Values

Figure B4c
Coho

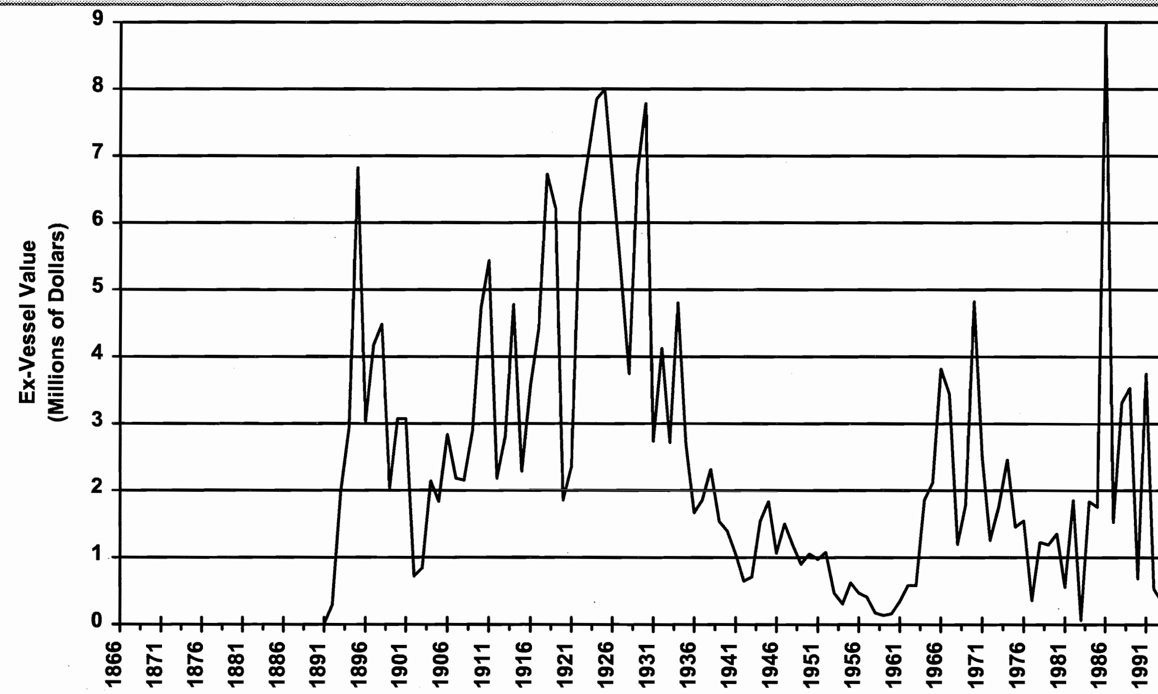
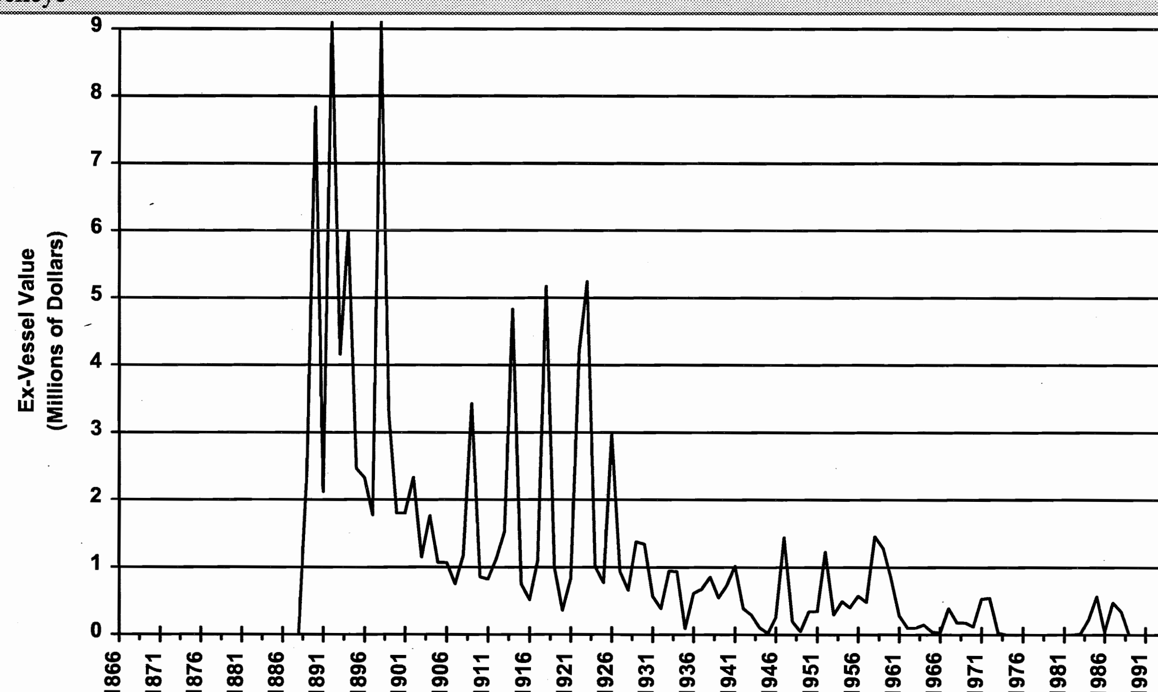


Figure B4d
Sockeye



Estimated Historical Columbia River Landed Ex-Vessel Values

Figure B4e
Chum

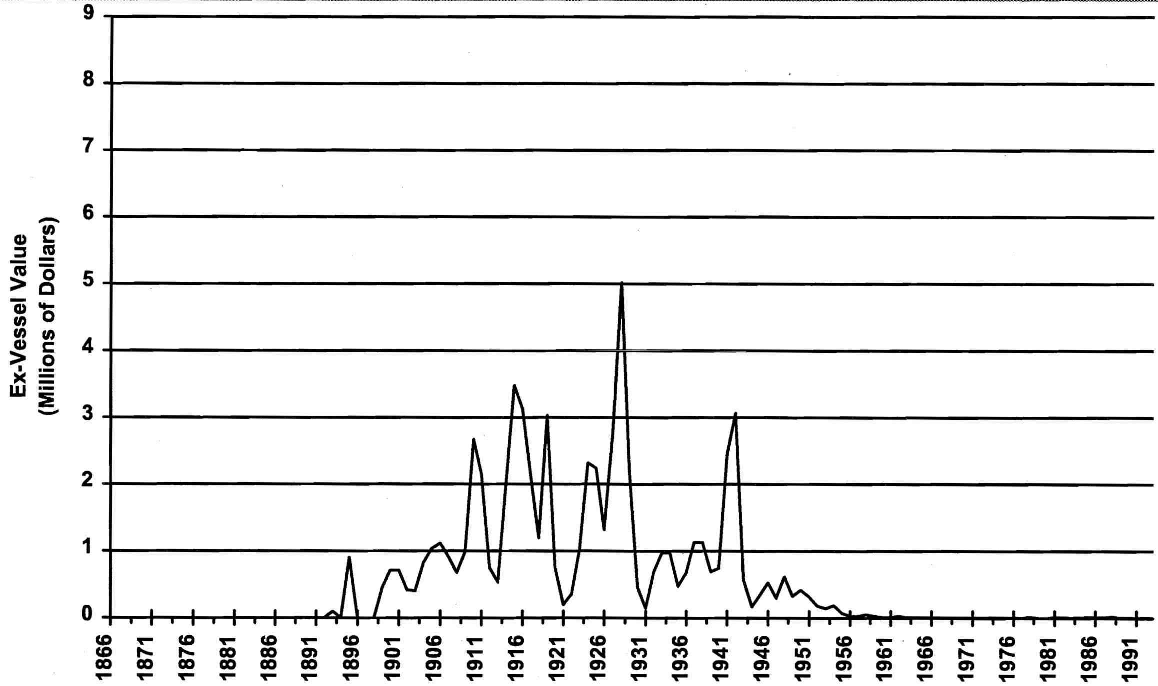


Figure B4f
Steelhead

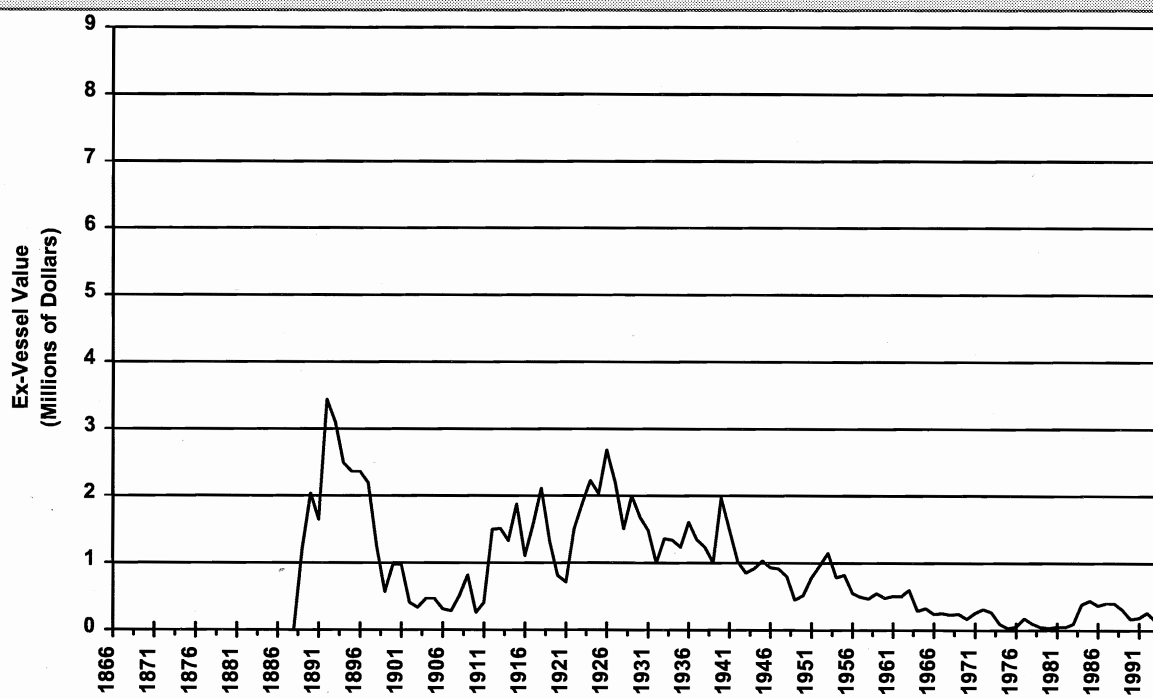


Figure B5a
Historical Columbia River Estimated State Income Impact

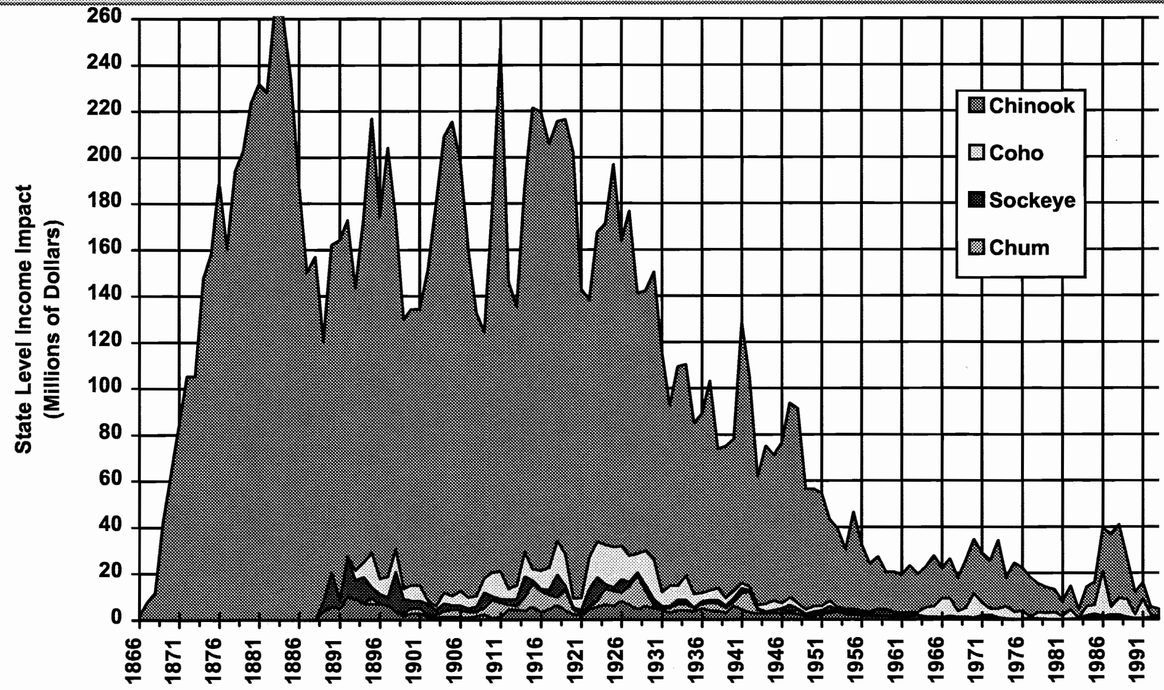


Figure B5b
Historical Columbia River Fish Landed

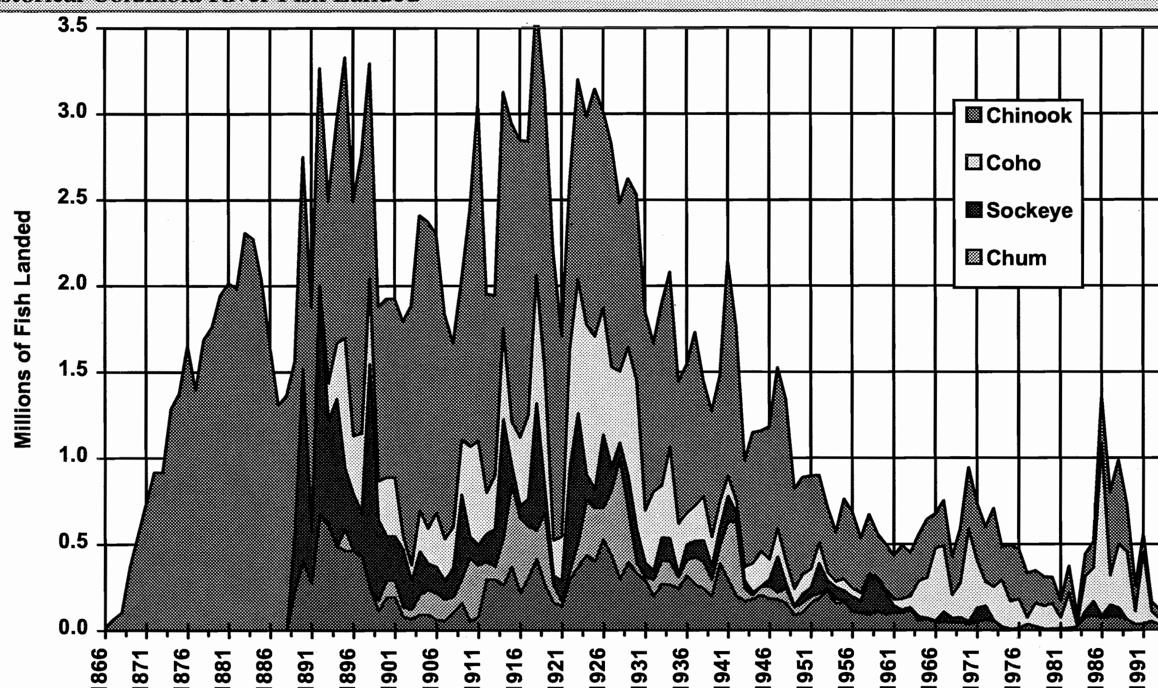


Figure B5c
Estimated Historical Columbia River Pounds Landed

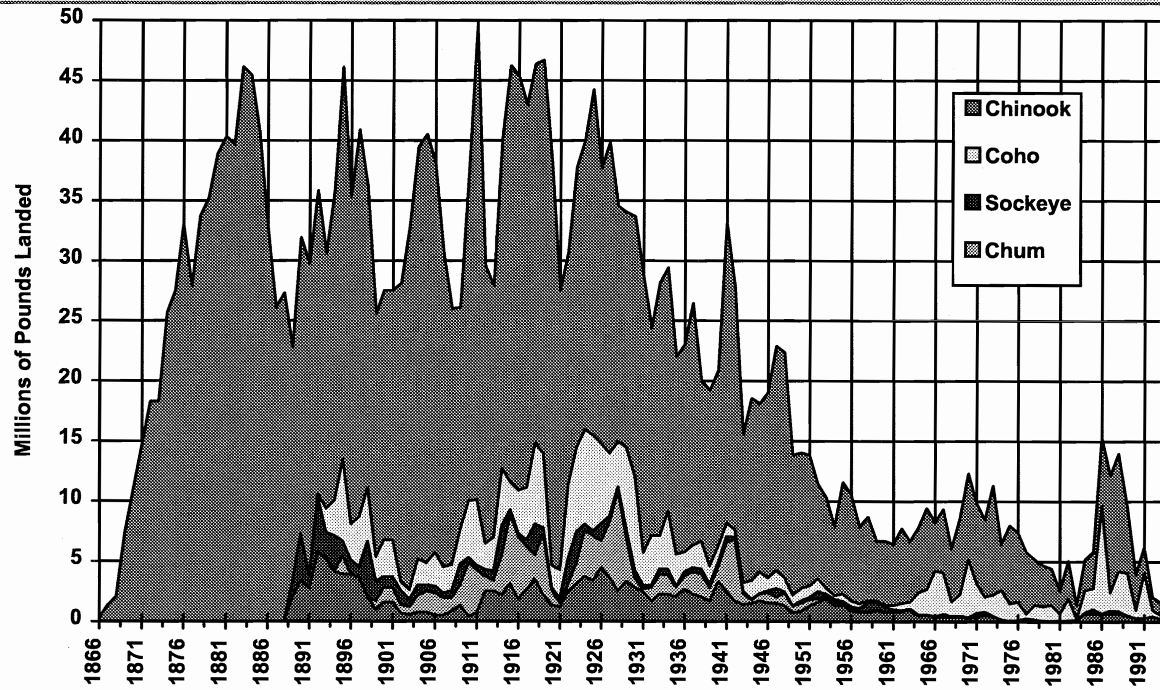
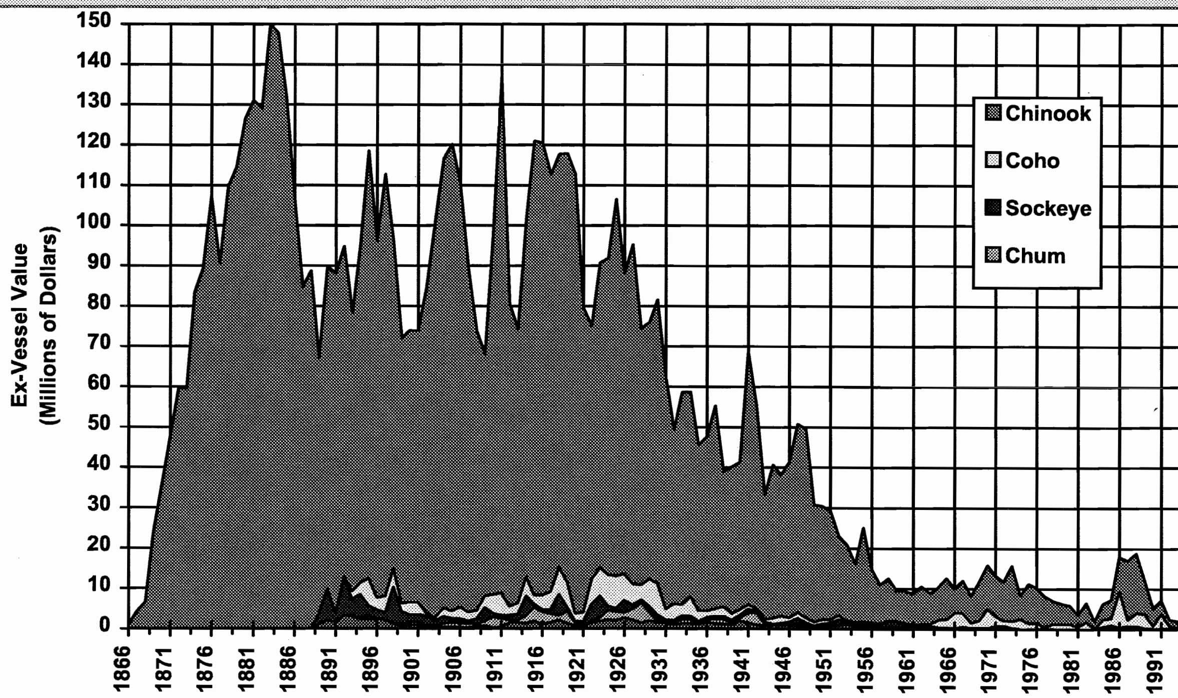


Figure B5d
Estimated Historical Columbia River Landed Ex-Vessel Values



Glossary of Terms

Anadromous — Fish species that hatch from eggs in fresh water and then migrate into the ocean, returning back as adults to fresh water to spawn. Species generally lumped together under the term "salmonids" are the most common family of anadromous fish.

Escapement — The total number of salmon "escaping" (returning) from the ocean to spawn in fresh water streams. A minimum escapement number is needed in each generation in order to continue the species at the same population levels (i.e., at least a 1-to-1 replacement from one generation to the next). Harvest levels are established only on the surplus above and beyond the minimum escapement levels required for replacement.

Ex-vessel price — the price per pound of salmon landed at the docks, as paid by the processor. This market price is only a small fraction of the total economic value to society generated by salmon because it is only at the beginning of a long chain of market transactions. However, the "ex-vessel price" establishes the market flow from that point onward, and careful records have been kept for many years.

Gear type — salmon are harvested with various types of gear, which use different boat and crew configurations, and thus have different impacts on the economy. Personal income impacts of harvested salmon thus vary by gear type used. Some of these gear types include "troll" (hooks on lines), "purse seine" (a towed net system), and "gillnets" (an alternative net system mostly used in-river). Economic analysis of fishery personal income impacts often needs to take into account the type of gear used to land the fish.

Salmon — any of 7 major species which are members of the genus *Oncorhynchus*, which includes chinook or king salmon (*Oncorhynchus tshawtscha),* coho or silver salmon (*Oncorhynchus kisutch),* coastal searun cutthroat (*Oncorhynchus clarki clarki)*, steelhead (*Oncorhynchus mykiss gairdneri),* chum salmon (*Oncorhynchus keta),* pink salmon *(Oncorhynchus gorbuscha),* and sockeye salmon *(Oncorhynchus nerka).* As a genus these species are also often lumped together and called "salmonids."

Smolt — juvenile salmon making or about to make the transition from fresh water living to ocean conditions where they will mature to adulthood.

Stocks — the stock is the basic unit of salmon fishery management. Because salmon return to their native streams to spawn, salmon within the same species can be further subdivided into genetically distinguishable subspecies, each of which is uniquely adapted genetically to its natal stream system or group of tributaries. The "stock" concept is loosely defined and is undergoing scrutiny as to whether it recognizes the genetic uniqueness of individual stream populations on a fine enough level to conserve genetic diversity (National Research Council 1996), but is still commonly used.

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